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AUTHOR Helgeson, Stanley L.; And Others
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ABSTRACT

This is a status report based upon the review, analysis, and summarization of literature related to pre-college science instruction, science teacher education, and needs assessment efforts. The report identifies trends and patterns in the preparation of science teachers, teaching practices, curriculum materials, and needs assessments in science education during the period 1955 to 1975. An archival search of the literature was conducted using such data bases as ERIC, reports to federal educational agencies, "Dissertation Abstracts International," "Education Index," state department of education reports, summary data from governmental and professional studies, professional journals and scholarly works, summary data from various accrediting agencies, and other available documents. Selection of documents for review was based upon: (1) generalizability of results based upon size of population, sampling techniques, and methods of analysis; (2) summarization of data or research reports (e.g., reviews of research); (3) importance or significance as indicated by publication in a refereed journal or as a committee report; and (4) representativeness of a type or kind of document (e.g., curriculum guides). The report is organized around four major considerations: (1) Existing Practices and Procedures in Schools (enrollment, school organization, curricular and instructional patterns, facilities and equipment); (2) Science Teacher Education (preservice education guidelines, certification, programs and research; science teaching today, curriculum reform, supply and demand, professionalism and responsibility, pressures and politics, and implications for science teaching); (3) Controlling and Financing Education (control and financing of schools; cost effectiveness of science instruction); and (4) Needs Assessment Efforts (general education needs and science education needs). (SLM)

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THE STATUS OF PRE-COLLEGE SCIENCE, MATHEMATICS, AND SOCIAL SCIENCE EDUCATION: 1955-1975
VOLUME I: SCIENCE EDUCATION

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Stanley L. Helgeson

Patricia E. Blosser

Robert W. Howe

Center for Science and Mathematics Education

The Ohio State University

1977

Supported by Contract NSF-C762067 from the National Science Foundation

to

the Center for Science and Mathematics Education
The Ohio State University

Stanley L. Helgeson, Project Director

SE 024 293

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VOLUME I. SCIENCE EDUCATION

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I. INTRODUCTION

The two decades, 1955-1975, are unparalleled in the degree of activity in science education. Millions of dollars were devoted to the cooperative involvement of scientists, educators, and learning theorists in the development of science curriculum materials. Extensive programs were conducted to upgrade and update the science content background of teachers and to train them in the use of the new curricula (Krieghbaum and Rawson, 1969). This marked the first major investment of federal monies directly in curricular and instructional concerns.

The Elementary and Secondary Education Act (ESEA) of 1965 continued the pattern of direct investment, initiating programs to deal with special groups within the educational community. Concern for the educational needs of students, especially the disadvantaged and deprived, and for program effectiveness evaluation was specifically mandated within this Act (Law, 1971).

The focus of this project was a status report on the impact of such activity in curriculum development, teacher education, instruction, and needs assessment. Specifically, the purpose of this project was to:

1. review, analyze, and summarize the appropriate literature related to pre-college science instruction, to science teacher education, and to needs assessment efforts; and

2. identify trends and patterns in the preparation of science teachers, teaching practices, curriculum materials, and needs assessments in science education

during the period, 1955-1975.

Procedures

The procedures followed in this project involved retrieval and analysis of existing literature, rather than the development of new documents.

A major source of documents resulted from a comprehensive search of the ERIC data base. This data base included 140,00 citations from professional and technical journals related to education and published on a monthly basis in Current Index to Journals in Education (CIJE). The companion publication, Resources in Education (RIE), announces non-journal publications such as research reports, state guidelines, program descriptions, etc. The RIE collection included 125,00 documents. Terms used in searching the ERIC collection are included in Appendix A. The output from this search yielded over 8,000 abstracts, many of which were duplicate citations owing to the comprehensive nature of the search. These abstracts were then scanned for relevance to the project objectives.

The Education Index and Readers Guide to Periodical Literature were also searched for pertinent documents, particularly for the period 1955-1965 which preceded the development of the ERIC system. These contain extensive listings of educational literature and account for several thousand documents.

Dissertation Abstracts International (DAI) was searched for doctoral dissertations related to practices, teacher education, and needs assessment in science education. This collection comprises a total of over 3,000 dissertations related to science education. During the 1955-1975 period 2,658 dissertations bearing on science education were reported. Terms used in searching DAI are listed in Appendix B.

Collections of federal agencies were also included in the literature search. The National Institute of Education (NIE) library was searched,

with special attention paid to historical and summary documents. Files of the National Science Foundation (NSF) were examined for research and evaluation reports, program descriptions, and reports of projects.

Questionnaires were sent to all state departments of education requesting information and documents dealing with state guidelines and policies, enrollment and course offering information, summary statistics, annual reports, planning documents, etc. (See appendix C)

Identification of state documents was aided by a publication produced by the Council of State Science Supervisors (1974), Data Utilization: A Key to Improved Science Education. This represents a laudable attempt to identify, categorize, and bring some consistency to science education data collected by the state departments of education.

Finally, visits were made to 14 states by personnel of the project staff. States from which data and information were received are listed in the following table.

TABLE 1

STATES INCLUDED IN PRELIMINARY ANALYSES

*Arizona
California
*Colorado
Delaware
Florida
*Idaho
*Indiana
*Iowa
*Kansas
Kentucky
Maryland
Massachusetts
Michigan
*Minnesota
Montana
*Nebraska
Nevada
New Jersey
New Mexico
New York
North Carolina
North Dakota
*Ohio
Oklahoma
*Oregon
Pennsylvania
South Carolina
Tennessee
Texas
*Utah
Vermont
Virginia
*Washington
West Virginia
*Wisconsin
*Wyoming

*States visited by project staff.

The total number of relevant documents identified in the search procedures described above was estimated in excess of 6000; an accurate count could not be made due to the duplication occurring through various modes of retrieval. Clearly the inclusion of all available documents would render the task of review and analyses impossible, the bibliography excessive, and the final report valueless. The decision was made to select and review representative documents. The determination of which documents to include was based upon:

1. generalizability of results based upon size of population, sampling techniques, and methods of analysis;
2. summarization of data or research reports, (e.g., reviews of research);
3. importance or significance as indicated by publication in a refereed journal or as a committee report;
4. representativeness of a type or kind of document (e.g., curriculum guides).

Such decisions are, of course, judgmental and subject to error. Yet not to make the decisions seemed the greater error. The final selection then, contained approximately 10% of those documents that might have been included. The authors of the report collaborated in identifying relevant documents. Further analyses were then conducted by the authors as individuals in developing the various subsections of the report. The documents were analyzed on the basis of presenting as accurately as possible the conditions, practices, and needs assessment efforts in science education as reflected by the literature.

While a large number of documents related to science education exist and have been identified, many exist that cannot be identified, or once identified, cannot be retrieved. Data produced by the various state departments are especially susceptible to becoming fugitive literature. Huge

quantities of data are amassed, analyzed and summarized to varying degrees, stored for a time, and shortly consigned to the "5th Avenue Warehouse", never to be found again. Locating data or reports more than five years old is an extremely difficult task. This is partly due to reassignment or turnover in personnel, partly due to insufficient storage and management capacity, but probably mostly due to shortage of funds to process the information effectively.

A related problem is the wide variation in the kind of information collected by state departments and other education agencies. Little consistency exists with respect to what data are collected, ways they are treated, or how they are reported. These data are collected primarily for the purposes of the state department or agency involved, rather than for the benefit of external purposes. As a result, when a need for information on a broad scale arises, the probability is low that the required data exist in a useful form. Some amount of consistency in the collection of data could yield great quantities of information in determining needs and trends in science education. In this regard, some mechanism by which information needs could be anticipated and appropriate actions taken in advance of the problem would be a boon to decision making.

Format of the Report

The remainder of the report is divided into five major sections. One section deals with existing practices and procedures in schools, another summarizes science teacher education, the following section deals with controlling and financing education, the next reports on needs assessment efforts, and the final section presents a summary and trends of needs and practices.

Within each section summary statements are presented for the major subsections followed by the documentation from which each was derived.

Because of space limitations and redundancy of information, the documents cited are selected as representative and do not consitute an exhaustive listing of applicable citations. Thus, one, two, or three documents are often cited where five to ten times as many documents exist and could have been included. It should be noted that many of the documents are from the last half of the twenty-year period rather than the first half. This stems partly from the ephemeral nature of much of the literature, but more importantly from two other considerations. First, the emergence of results, trends, and patterns is better reflected in the more recent literature since these are not instantaneous apparitions. Second, the recent literature indicates the existing conditions from which decision makers must determine factors affecting educational policies. If a historical review is to assist science education, the policy implications of past events must be considered for the future.

II. EXISTING PRACTICES AND PROCEDURES IN SCHOOLS

Data for this section were obtained from a review of over 600 individual research studies, state and federal documents, and journal articles. Many are cited in the bibliography. Key studies are referenced to support all statements to which they are related, though not all references are used to support all statements to which they relate; such a pattern would use too much space for this report.

PRACTICES AND PROCEDURES IN SCHOOLS

General School Enrollment

1. Enrollments in public elementary schools were increasing from 1955-1969. Since that time enrollments have been declining. Forecasts predict continued decline until at least 1984 or 1985.
2. Enrollments in public secondary schools were increasing from 1955 until 1976. Enrollments will probably decline in the future until at least 1984 or 1985.
3. Enrollment increases impacted the schools in many ways. Included were expansion of staff, program offerings, and buildings.
4. Enrollment decreases are impacting the schools in many ways. Most of the more obvious effects are due to reduction in revenues.
5. Some investigators are predicting a possible increase in school enrollments beginning in the middle 1980's. This increase will not bring enrollments back to present levels, but will have an impact on staffing, facilities, and material needs.
6. A substantial number of students (nearly 30 percent of the U.S. total) are enrolled in less than 200 school districts.

Data analyzed indicate enrollments in public elementary schools increased until 1969 and then began to decline (see Table 2, p. 8). If data for only grades K-6 are analyzed, it appears the peak enrollment occurred in 1968.

TABLE 2

Enrollment in Public Schools Grades K-8
Fall 1965 to 1985 (in thousands)

Year (Fall)	K-8 Enrollment	Year	K-8 Enrollment
Recorded[1]		Projected[2]	
1965	30,563	1977	29,463
1966	31,145	1978	28,753
1967	31,641	1979	28,199
1968	32,226	1980	27,876
1969	32,597	1981	27,819
1970	32,577	1982	27,923
1971	32,265	1983	28,158
1972	31,831	1984	28,446
1973	31,353	1985	28,830
1974	30,921		
1975	30,556		
1976	30,072		

1. Statistics of Public Schools, 1965-75. National Center for Education Statistics, Washington, D.C., 1976.
2. "NCES Projects K-12 Enrollment Upturn, to Begin in 1984." Phi Delta Kappan, 58(9):714, May, 1977.

The increase in enrollment in the elementary school was due to a number of factors; the major influence was increase in the birth rate. Other factors influencing the increase were immigration and increasing the holding power of the schools.

Since 1969, enrollments have continued to decrease. Current projections forecast a continued decrease until 1984 or 1985. Since the current major factor influencing the elementary school enrollment is the birthrate, these projections should be very accurate at least through 1982; unless there is a substantial change in the birth rate, or changes in non-public elementary school enrollment, these projections should be close through 1986-87. The projected low enrollment represents about 2.2 million fewer students than in 1976 and 3.7 million fewer students than in 1969. Public secondary school enrollments (grades 9-12) have increased each year since 1955 (Table 3, p.10) until 1977. Between 1955 and 1976 enrollments in public secondary schools more than doubled. This increase was caused primarily by the increased birth rate, but also was aided substantially by the increased holding power of the schools.

Between the 1940's and the 1970's the percentage (national average) of ninth grade students who stayed in school and graduated from high school increased from about 58% to approximately 79% (Based on analyses of reports from 27 states and NCES data). Significant differences still exist among many of the states; a number of the states approach or exceed 90% retention while some schools are substantially below 80%.

Based on current elementary school enrollments, the current non-public school enrollment trends, and the expected holding power of the public schools, a decrease in enrollment is projected until at least 1985. The

TABLE 3

Enrollment in Public Schools Grades 9-12
Fall 1955 to 1985 (in thousands)

Year (Fall)	9-12 Enrollment	Year	9-12 Enrollment
	Recorded[1,3]		Projected[2]
1955	6,918	1977	14,258
1957	7,905	1978	14,101
1959	8,531	1979	13,725
1961	9,617	1980	13,233
1963	10,936	1981	12,699
1965	11,610	1982	12,190
1966	11,894	1983	11,912
1967	12,250	1984	11,878
1968	12,718	1985	11,928
1969	13,022		
1970	13,332		
1971	13,816		
1972	13,913		
1973	14,077		
1974	14,132		
1975	14,281		
1976	14,321		

1. Statistics of Public Schools, 1965-75. National Center for Education Statistics, Washington, D.C., 1976.
2. "NCES Projects K-12 Enrollment Upturn, to Begin in 1984." Phi Delta Kappan, 58(9):714, May 1977.
3. Digest of Education Statistics, 1975. National Center for Education Statistics, NCES 76-150. U.S. Government Printing Office, Washington, D.C., 1975.

projected low point in 1984 represents about 2.5 million fewer students than those enrolled in 1976. Unless the non-public school enrollment pattern changes, these projections should be accurate. An analysis of the elementary school data and census data on birth rates provide data that should be reasonably accurate until the 1990's. Monitoring the annual birth rate and the number of births will provide good correction procedures to extend these data and avoid "enrollment surprises."

The birth rate between September, 1976, and April, 1977, shows about a six percent increase compared to last year. In addition, the number of marriages is up and there is no increase in the divorce rate. ("Babies...", Science News, 1977) While all evidence suggests the total enrollment in 1990 will be substantially less than the enrollment in 1969, the number of school age children should show an increase beginning in the middle 1980's. Based on current estimates, enrollment increases will have the greatest impact in suburbs and in the South and West. ("Slight...", Information, 1977)

The impact of the expanding enrollment upon the public schools has been obvious in many ways: (1) increases in school staff, both instructional and non-instructional; (2) increases in expenditures for school buildings; (3) increases in numbers of buildings in urban and suburban locations; (4) increases in student enrollments in many schools; and (5) increases in students taking various courses in the schools (derived from a number of state and federal documents with statistical data).

The impact of the reduction in enrollment has been described by many writers and presents both a problem and a possible opportunity to many school districts. Obvious problems are: (1) budget reductions based on enrollment; (2) need for fewer or smaller schools; (3) reduced need for some equipment and transportation items; (4) fewer students per grade and

in many cases, per course; and (5) need for fewer teachers under current patterns.

The reduction in enrollment can provide opportunities for modification of the school and instructional program. Capital debt and interest could be reduced and used for other purposes, class and course enrollment could be reduced, school building enrollments could be reduced, and space allocated to various programs could be increased.

Odden (1976) made several points in a recent publication.

1. Declining enrollments have had the greatest impact in the elementary schools, though the middle schools and high schools will be affected in the next decade.

2. Declining enrollments are uneven among school districts. Areas that have a low birth rate and have a negative movement of people to the area are affected most severely. Areas that have a positive movement of people to the area are not affected as seriously.

3. The largest and smallest school districts are affected most severely. Central cities appear to be suffering the greatest losses.

4. Declining enrollment districts tend to have above average per pupil expenditures (total, instructional, operation, and fixed expenditure), lower than average pupil/teacher ratios, and above average salaries.

School consolidation has also influenced school programs and operations. Between 1932 and 1974 the number of school districts was reduced from about 127,000 in 1932 to 35,700 in 1961-62, to 17,200 in 1971-72, and 16,700 in 1973-74. These changes have been accompanied by eliminating many small schools, building more facilities for larger schools, larger staffs, and a greater variety of school offerings. (Education Directory: Public School Systems, 1971-1972, 1972; "A Statistical Profile: Education in the States, 1973-74," Compact, 1974).

Since school districts were consolidated and as enrollments increased, a small number of school districts have come to enroll a substantial percentage of

the students in public schools of the U.S. Data indicate that the 184 largest school districts have about 29% of the students enrolled in public schools; the 730 largest have about 45-48% of the students enrolled. Based on these statistics it is obvious that a relatively small number of school districts determine the educational programs for a large number of students.

School Organization Patterns

---

1. Most elementary students are enrolled in schools with grades 1-6, K-6, 1-8, and K-8.

2. The most common pattern for teaching science in elementary schools is the self-contained classroom. Increasing emphasis on departmentalization and special teachers is occuring in grades 6-8.

3. Most students in secondary schools are enrolled in schools with grades 7, 8, and 9 or 7 and 8 and in high schools with grades 10-12 and 9-12.

4. Secondary school science is taught primarily by teachers who have received their training in science.

Several investigators and agencies have studied the organization patterns of elementary schools and teaching science. These include Blackwood (1965a,b); Steiner, et al. (1974); Howe, et al. (1974); National Center for Education Statistics (Progress of Education..., 1973; Statistical Survey..., 1975; Digest of Education..., 1976).

Most elementary students are enrolled in elementary schools that include grades 1-6, K-6, 1-8, and K-8. During the 1960's and 1970's there has been considerable interest in the development and organization of middle schools. The term middle school means different things to different people; hence, it is not surprising to find the emergence of many schools with different patterns of organization related to this concept (such as grades 4-6, 4-5, 5-6, 5-7, etc.). Prior to enrollment declines, the num-

ber of these types of schools and the number of students enrolled in these schools was increasing. Since enrollment declines have taken place, there has been an effort to close elementary schools in many communities (particularly urban) due to smaller school enrollments; this action appears to have had the effect of reducing the number of middle school programs.

The most common pattern for teaching science in elementary schools is in the self-contained classroom. Instruction by a special teacher is seldom the pattern prior to grade 3. From grade 4 to grade 8 the percentage of instruction by special teachers or science teachers increases with the grade level. Data indicate increasing emphasis on instruction by a special teacher or science teacher in grades 6-8 (Blackwood, 1965a, 1965b; Steiner et al., 1974; Howe et al., 1974; Howe, 1977).

Data indicate that an increasing number of teachers were being provided with special help for teaching science through the school year 1974. While specific data directly supporting a reduction in such assistance were not located, documents examined indicated a reduction in supervisory positions which probably means a reduction in such support.

The majority of the students in secondary schools are in junior high schools with grades 7, 8, and 9, or 7 and 8, and in high schools with grades 10-12 and 9-12. A substantial number of students in grades 7 and 8 are housed in elementary schools including one or more of the lower grades. Relatively few students are enrolled in high schools with patterns different from those listed (Schlessinger et al., 1974; White et al., 1974; NCES 1973, 1974, 1975).

Secondary school science is taught primarily in departmentalized subject areas. Analyses of studies from the mid 1950's to the early 1970's

indicated some use of team teaching approaches, but the individual teacher teaching a class is by far the most common approach. The large majority of the schools are on daily schedules using periods. The usual school day in the mid 1950's was a six or seven period day divided into 45-60 minute periods; according to research studies and state reports this is still the most common pattern. Many teachers feel this type of schedule reduces the opportunity for many science laboratory and outdoor activities; however, probably fewer than 10% of the schools have any modular schedule or other type of plan that differs substantially from the usual period plan or a modified single/double period plan. (Schlessinger, et al., 1973; Howe, 1977.) Substantial modification of daily school schedules does not appear to have gained much support in the past two decades, though many teachers and administrators have written about the usefulness of flexible schedules that allow for time variations.

Elementary School Science

1. Prior to the late 1950's the curriculum of an elementary school was based primarily on a textbook. A curriculum for most schools was a textbook series for grades 1-6 (8) or two series one used for the lower grades and the second used for the upper grades.

2. With the use of Federal funds (mostly NSF) alternatives to the existing materials were developed in the 1960's. These materials had a marked effect on both classroom instruction, other instructional materials prepared by publishers, and curriculum guides.

3. Data indicate about 30% of the elementary schools have used or are using the NSF sponsored materials.

4. During the 1970's several publishers produced materials that are modifications of earlier NSF sponsored materials. These modifications have been based on feed-back from use of the earlier materials.

5. Many of the curriculum materials produced during this period of time show a marked influence of the ideas of Piaget, Gagne, and Bruner.

6. Summaries of objectives for elementary school studies stated by teachers, administrators, and science educators in the 1960's and 1970's show substantial similarity.

7. Content of many programs produced since 1955 show substantial agreement with the objectives reported from surveys.

8. Recent materials show the impact of concerns about the environment and energy and natural resources.

9. During the past five years there has been growing concern on the part of some educators and citizens that knowledge objectives of the elementary school program were de-emphasized too much. Some of the recent materials illustrate this concern as do textbook adoption patterns.

10. While there are substantial data regarding implementation and use of materials, there are relatively few data on <u>quality</u> of use.

During the late 1950's and the early 1960's considerable interest focused on what should be taught and how it should be taught. During the middle to late 1950's textbooks were used by most teachers as the principal tool for teaching science. Studies indicate that about 80% of the primary teachers and 90% of the intermediate teachers based their instruction on a single textbook (Blackwood, 1965a, 1965b; Steiner et al., 1974; Howe et al. 1974; Maben, 1971; Webb, 1972; Nelson, 1973.)

The feeling was that if science for elementary schools was to be improved there should be more care and emphasis on the selection of content (facts, concepts, principles), reduction in the amount of content to allow for more depth, better organization of the way content was taught (sequence, articulation, examples, etc.), more emphasis on processes of science, more "hands on" science instead of reading about science, and use of a greater variety of media and materials for teaching science.

Extensive NSF support was given to the development of a number of alternatives to textbook programs in the 1960's. Hausman (1976) provides a good brief discussion of this effort and includes such programs as the Elementary Science Study (ESS), Science - A Process Approach (SAPA), Science Curriculum Improvement Study (SCIS), Minnemast, COPES, USMES, and others. Each of these projects viewed the needs, the problems, and possible solutions and developed what they thought were useful materials for teachers and students. The projects clearly offered alternatives both to the current textbooks available at the time, and in most instances to each other. The projects also seemed to respond to the desired objectives for teaching science identified by administrators and teachers as reported by many surveys conducted in the 1950's and 1960's.

These materials had a marked effect both on classroom instruction in many schools and on other curriculum materials currently being prepared.

State data (through 1975) and survey reports (such as those by Steiner et al., 1974; Howe et al., 1974; and others) indicate that about 30% of the students in the U.S. in elementary schools are in buildings which have used or are using these materials. Use has varied extensively from state to state and also within states. In 1971 about 14% of the schools were using SAPA, 8% were using ESS, and 5% were using SCIS (Steiner et al., 1974; Howe et al, 1974). More recent data obtained from state reports through 1975 indicate an increase in the use of SCIS, ESS, and SAPA. Use of SCIS and ESS is estimated for schools in which 17 and 12 percent of the students are enrolled. Use of SAPA is estimated for schools in which 20% of the students are enrolled. Schools that indicated the use of one of the NSF curricula frequently used two or more.

During the 1970's several publishers have produced "hybrid" materials. In a recent volume by Hausman (1976), several of these programs are discussed. Examples of these modifications of NSF materials are the Modular Activities Program in Science; Science, People, Concepts and Processes; Elementary Science Learning by Investigation; the Ginn Science Program; and Space, Time, Energy and Matter. Modifications made in many of these are based on feedback from teachers regarding NSF projects. Most of these reflect consideration of the concerns mentioned on page 17.

It is evident that the content and activities of these materials is different from the textbooks of the 1950's. Curriculum guides and teacher guides produced by states and local school districts since 1972 are closer in emphasis to the NSF project materials and recent "hybrid" materials than to the textbooks of the 1950's.

Analyses of reviews of research produced by ERIC/SMEAC since 1966 (see bibliography); Belanger, (1969); Ramsey and Howe,(1969a, 1969b, and 1969c); and Shulman and Tamir (1973) indicate the ideas of Bruner, Schwab, Gagne, and Piaget have had an influence on the psychological and structural organization of the post-1960 curricula. The ideas of Ausubel have also been considered and have been used as the basis of a number of research curriculum studies.

Major objectives for the elementary school curriculum as stated by individuals indicate divergent points of view. Summaries of the opinions of many teachers, administrators, and science educators, however, show a clustering of what they believe should be taught; these objectives do not appear to have changed substantially since 1960 (Blackwood, 1965b; ERIC/SMEAC Reviews of Research; and others).

Content of many of the materials produced since 1955 makes them more consistent with major objectives identified as desired in surveys such as those by Blackwood (1965b) and others. There is more emphasis in many programs on concepts, processes of science, attitudes toward science, and use of laboratory (hands on) activity. There also is more emphasis on recent concerns such as pollution, natural resources, energy, etc. The recent NAEP studies, state minimum competency program discussions, and comments of some educators and citizens are raising questions regarding the emphasis of these materials and programs. Questions are being raised as to whether these programs have placed too much emphasis on objectives other than knowledge. The impact of this concern is being seen in the pattern of adoptions of textbooks and use of materials; there appears to be a reduction in the emphasis on laboratory work in many schools.

There are few data available to relate material use and quality of instruction. Most of the research that is available regarding classroom instruction includes reports on a few teachers or a group explicitly involved in an inservice program curriculum development project or implementation activity.

Studies of teachers in specific programs frequently indicate significant differences in favor of the treatment (Balzer, et al.,1973; Ramsey and Howe, 1969c). Most of these studies, however, have not followed teachers over time to determine the retention or improvement of instruction.

Investigations of samples of practicing teachers not involved in a particular program frequently have shown many teachers using different materials in similar ways. Thus, while there are substantial data to indicate extensive use of various materials, how these materials are used is not well documented.

Research reviewed for this and other documents indicates the teacher's philosophy regarding what science should be taught and how science should be taught has a strong influence on the way teachers teach. This is frequently not a variable included in data collection; hence, it is not correlated or used as a correlate, selection criterion, or as a factor in many studies.

Secondary School Science

1. In the early 1950's there was growing concern regarding the need for technically trained manpower, the need for improving understanding of science, and the concern that Russia was getting "ahead" of us in science and technology.

2. Substantial Federal funding was provided to create new instructional materials for the secondary schools. These materials tended to show a reduced emphasis on "practical science" and emphasized concepts and processes of science. Until the early 1970's they did not reflect much emphasis on the interaction of science and society.

3. Data indicate the percentage of students taking science courses in grades 7, 8, and 9 has increased since 1955. The total number of students has decreased due to declining enrollments.

4. Data indicate the percentage of students taking science in grades 10, 11, and 12 increased from 1955 to 1973. Data reviewed indicate a slight reduction for 1974-76.

5. Earth Science courses experienced rapid expansion from 1955 through the 1970's leading to a shortage of qualified teachers.

6. Biology, Chemistry, and Physics remain the predominant courses in grades 10, 11, and 12, but a number of other courses such as oceanography, physiology, integrated science, and environmental science are being offered and are increasing in enrollments.

7. Concerns regarding the material developments of the late 1950's and 1960's have led to further material development.

8. The objectives for teaching secondary school science appear to be in transition. Increased emphasis is being given to environmental concepts, societal concerns and world problems, decision making, and interdisciplinary studies.

9. As in the elementary school, there are few data on the quality of use of materials in school settings.

The science programs in the secondary schools of the U.S. have also undergone considerable change from 1955 to 1976. In this discussion percentage of enrollment will frequently be used; this is because net enrollments at most levels are now declining due to fewer students in the schools.

Science materials have received considerable attention since 1955. Prior to Sputnik I, there developed in the U.S. concern regarding the education and training of specialists in science, mathematics, and engineering. This concern was primarily related to national security and the scientific and technological progress being made by the Russians. At that time the curriculum in most schools was predominantly the textbook and curricula were constructed by purchasing a series of textbooks. Data obtained from states and reviews of surveys indicate the Holt publications were the curriculum for a large number of schools in grades 7-12; in biology, chemistry, and physics Holt dominated the market and has continued to control a strong share of the market.

Following Sputnik I, the National Science Foundation became extensively involved in development of instructional materials. In addition, The Elementary and Secondary Education Act (ESEA) and the National Defense Education Act (NDEA) provided considerable financial support for curriculum development, purchase of equipment, and teacher education.

The literature contains many articl written to identify the "need" for substantial material development. Included by many writers are the following:

1. Update the material to make the content more accurate.
2. Place more emphasis on current science endeavors.

3. Stress fewer ideas or concepts and provide more depth.

4. Involve writers who are "closer" to scientific research and who can reflect the current state of science.

5. Give more emphasis to inquiry and the processes of science.

6. Emphasize the laboratory as a place for investigation.

7. Provide multi-media materials for teaching and learning science.

8. Give teachers up-to-date content.

As a result of the financial support of the Federal Government, a number of projects were developed. Included among these were the Physical Science Study Committee (PSSC), Biological Sciences Curriculum Study (BSCS), Chemical Education Materials Study (CHEMS), Chemical Bond Approach (CBA), Earth Science Curriculum Project (ESCP), Intermediate Science Curriculum Study (ISCS), Project Physics, Introductory Physical Science (IPS) and others.

As time progressed special sets of materials were developed that were for advanced and second year students, focused on modular approaches for using laboratories, provided special materials for slow learners, and others. A review of the Reports of the International Clearinghouse on Science and Mathematics Curricular Developments (See bibliography for a listing of the 10 reports produced by Lockard and his associates) documents and describes many of these developments.

These NSF efforts have clearly had an impact on other science instructional materials. Modification of other textbooks and laboratory manuals reflect the influence of the NSF materials regarding topics considered, types of laboratory activities, content deleted, and organization of the materials.

Materials produced during most of the last two decades tended to show a reduced emphasis on "practical" science (how things work, industrial processes, chemistry of household items, etc.)and, until the early 1970's, generally did not reflect much emphasis on the interaction of science and society.

Reports of students' lacking practical knowledge in science by National Assessment and others has led to increased interest in this aspect of science. While no "flourish" of materials has resulted, there are materials being produced mostly related to consumer science, and courses being developed that emphasize the practical aspect of science.

Emphasis on science and society has been receiving increased interest in the literature in materials such as Project Physics and Human Sciences and in many courses that emphasize the environment, science, and society. There clearly has been increased interest in this area as indicated by increased enrollments reported by states.

Relatively few content areas appear to be banned or restricted on a widespread basis. A review of the literature shows that only human reproduction and evolution are restricted in any substantial number of schools. Restrictions on teaching human reproduction appear to have been reduced substantially in the last decade. Evolution continues to be a debated topic in some states and localities.

The percentage of students taking science courses in grades 7, 8, and 9 increased from 1955 through 1972 or 1973 and since that time has remained about constant. Data anlyzed from 27 states, research studies, and

surveys do not support the claims some people have made about substantial reductions in the percentage of students enrolled in science. A reduction in the total enrollment has affected the total number of students enrolled courses; in general, the total number of students in science courses has decreased.

General Science was the most common course in grades 7, 8, and 9 in the middle 1950's. Starting in the late 1950's and continuing into the 1970's there has been a consistent decline in general science courses and enrollments. The most common replacements for general science are courses in (1) life science, (2) physical science, and (3) earth science; the percentage of students enrolling in these courses continues to increase.

Enrollments in earth science showed a sharp rise during these two decades. Earth science enrollment has increased from about 70,000 in the late 1950's to well over one million in the mid-1970's. (Mayer, 1977; NCES, 1976; Schlessinger, et al., 1973; data from 29 states). Most of this enrollment increase was in courses offered in grades 7, 8, and 9. This rapid increase in earth science offerings has led to a shortage of qualified earth science teachers in many states.

Enrollments in courses titled ecology, environment, marine science, oceanography, space and aviation science, and photography have also increased; in many schools these courses are offered for only a semester. These courses count for part of the increase in junior high school science enrollment and also for part of the decrease in enrollments in other courses.

The percentage of students taking science courses in grades 10, 11, and 12 appears to have increased since the mid 1950's through the early 1970's. Analyses of state data and reports of the National Center for Education Statistics indicate an increase of about 5% from 1955 to 1973.

State data reviewed for 1974-76 indicate a small reduction in the percentage of students taking science courses. Numbers of students enrolled in some selected courses according to the NCES are listed in Table 4 . For about 50% of the students, biology is their last science course, usually in grade 10.

The percentage of students taking biology in grades 10, 11,and 12 increased from 1955 through the early 1970's. This increase was due to many factors including increased emphasis on science. Analyses of state reports suggest that a major factor in the increase was the increased holding power of the schools; most students had to take a science course to meet graduation requirements and it appears they frequently selected biology. The percentage of students taking biology appears to have decreased slightly in the past three years. Some of the enrollment drop in biology has come from the selection of other science courses; many of these courses such as ecology, anatomy, oceanography, physiology, and integrated science contain biological science concepts. If these courses are included with biology enrollments the percentage of students being exposed to biological science concepts has not decreased. In most states over 80% of the students enroll in a biology course at sometime during their high school program.

Biology courses in the late 1950's were primarily based on the Modern Biology book published by Holt. The three textbooks (blue, yellow and green) developed by the Biological Science Curriculum Study (BSCS) were adopted by many schools during the late 1950's, 1960's, and 1970's. Use of the BSCS materials continued to increase until the early 1970's. Data indicate about 40% of the students studying biology were using one of the three BSCS versions at that time; about 35-40% of the students were using the Modern Biology text. Recent data obtained from states (1974-76) suggest a decline of about 5-8% in the use of the BSCS materials.

TABLE 4

Number of Public School Pupils in Grades 9 to 12 Enrolled in Specified Subject Areas Selected Years[1]

	1948-49	1960-61	1972-73
General Science	1,121,980	1,826,087	1,096,020
Biology	995,930	1,776,306	2,868,352
Botany	7,670	4,996	47,188
Zoology	5,051	5,924	61,864
Physiology	53,592	65,953	109,588
Earth Science	20,575	76,564	558,654
Chemistry	412,401	744,820	1,028,591
Physics	291,473	402,317	583,105

1. The Condition of Education, 1976 Edition. National Center for Education Statistics, Washington, D.C., 1976.

Chemistry enrollments showed a small percentage of enrollment gain in the 1960's and early 1970's. Since 1971 the percentage of students enrolled in chemistry appears to have declined slightly. Most students in chemistry in the late 1950's were using Modern Chemistry, a textbook published by Holt. Two NSF projects were supported to produce materials for secondary school chemical education. The Chemical Bond Approach (CBA) never was used by a substantial number of schools. The Chemical Education Material Study (CHEMS) publication received greater acceptance by the schools. Data indicate many schools quickly moved to use CHEMS in 1960's. Use of the materials appears to have peaked in the early 1970's at about 30% of the students studying chemistry. There has been a marked decline in the use of CHEMS materials during the last four years. This is primarily due to the availability of other materials that incorporate many of the CHEMS activities and approaches to teaching chemistry. The Modern Chemistry text (Holt) has continued to hold a substantial share of the student use. Data from state reports and surveys indicate that in 1974 about 50% of the students studying chemistry were using this book.

The percentage of enrollments in physics and physical science increased slightly in the 1960's and early 1970's, but never showed a substantial increase. Since 1971 or 1972 the percentage of students studying physics and physical science has decreased slightly; the percentage of enrollment in physics has decreased more than the percentage decline in physical science.

The major physics book in use in the late 1950's was Modern Physics published by Holt. PSSC was introduced in 1958 and gained in use until the late 1960's or early 1970's. Data indicate the use of PSSC peaked at about 30-35% of the students enrolled in physics. Since the early 1970's the use of PSSC has been declining. Project Physics was introduced in 1969; the use of these materials has been increasing and probably accounted for

about 20-22% of the students studying physics in 1975 (Howe; 1977, Watson, 1977; and data obtained from 27 states). Modern Physics continued to be used by over 40% of the students throughout this time span.

Physical Science courses were offered in many high schools (about 50%) in the 1960's and 1970's for students who did not take chemistry or physics or as preparation for these courses. Enrollments in the courses increased substantially in the 1960's and early 1970's; Introductory Physical Science (IPS) was used as the instructional materials by a large number of the schools. About 40% of the students studying physical science in 1971 were using IPS (Schlessinger et al., 1973). Since the early 1970's the percentage of students studying physical science has declined, as has the use of IPS.

Percentage enrollments in advanced courses (second year biology, chemistry, and physics) have shown a slow, but steady increase. Advanced Biology and Second Year Biology courses have shown the most gains. From data available it appears that about 3 % of the students in grades 10, 11, and 12 are enrolled in such courses, primarily in larger high schools.

A number of other courses are frequently offered in high schools, as in junior high schools. Courses such as integrated science, ecology, oceanography, space science, anatomy, physiology, and environmental science are offered by many schools. Data from state records and surveys (NCES, 1976; Schlessinger, et al., 1973; Howe, 1977) indicate the number of alternative courses being offered has shown a substantial increase since the late 1950's. Many of these courses are offered in one semester units; to satisfy a graduation requirement a student frequently takes two such units or two different courses. Data indicate substantial increases in the enrollments in these courses during the last five years.

INSTRUCTIONAL PATTERNS

A number of concerns have emerged from the curriculum development of this period. Some materials have been and are being produced to provide solutions to some of the problems. Among the concerns were those previously mentioned, the lack of practical or applied science and the lack of emphasis on sience and society. Other concerns include the difficulty of the materials produced (including content and reading), lack of interdisciplinary emphasis, lack of emphasis on technology, and continued lack of articulation in curricular materials.

With the exception of ISCS and a few other projects, little has been done to change the structure of the teacher-student relationship in secondary school science classes.

The minimum competency movement has had very little noticeable effect on secondary school science at this time. The "back to basics" movement and the financial situation of the last several years have had considerable impact in many communities and tend to be reflected in materials being reviewed and in the amount of time devoted to laboratory activities and use of field trips in the curriculum. A review of materials being used in several states, ERIC user requests, and surveys (Schlessinger et al., 1973; Howe, 1977; Bila and Bligh, 1968; Cornell et al., 1974) indicate materials being selected by a number of schools, especially at the junior high level, tend to reflect less emphasis on laboratory activities and field trips and more emphasis on materials that can be used for reading. It is difficult to totally separate the reasons for this pattern.

The objectives of secondary school science appear to be going through a transition. A variety of courses have been developed to reflect environmental concepts, societal concerns and world problems and interdisciplinary

relationships in content. Hurd (1976) and others have written about a new context for teaching biology. The review of the literature and courses being offered in some schools indicate the movement includes other content areas as well.

Impact of State Adoption on Instructional Procedures Materials

A study by the Institute for Educational Development (Selection of Educational Materials in the United States Public Schools, 1969) indicated they found little difference in 24 "state adoption" states and 26 "non-adoption" states. They reported the systematic differences in patterns of materials selection that were identified seemed to be based on the size of the district involved, whether it is urban or rural, its social and economic character, and the attitude of the school system personnel who are influential and involved in materials selection. The study also reported that financial limitations were considered as the most important constraint on material selection. Data from a variety of surveys and other studies would tend to support most of these findings.

Elementary School Science

A number of surveys have been conducted to determine instructional practices in elementary schools. The most extensive studies regarding elementary schools are those by Blackwood (1965b) and a team at The Ohio State University (Steiner et al., 1974; Howe et al., 1974). Data from other studies and state reports were used to extend and to verify or dispute the major surveys. Reviews have also provided substantial information regarding practices. These include reviews by Haney et al., 1969; Gallagher, 1971; Cunningham and Butts, 1970; Smith, 1963; Lee et al., 1965; R.D. Anderson, 1973; Trowbridge et al., 1972; Balzer, Evans and Blosser, 1973; Rowe and DeTure, 1975; and Herron et al., 1976.

The amount of information regarding practice is substantial. Hence, it is necessary to summarize and to select key points.

1. Average class size has been reduced between 1960 and 1975, especially in larger school districts. Average class size has gone from over 30 in the late 1950's to approximately 24-25 in the 1970's.

2. Amount of time devoted to science has increased in the upper grades and appears to be about the same in the lower grades. Data obtained from Blackwood (1965b), Howe et al,(1974) and state reports indicate the amount of time devoted to science increases as the grade level increases. Data indicate about 60 minutes per week is devoted to science in grade 1 increasing to 110-140 minutes per week in grades 6,7, and 8. More time is devoted to science in classes using NSF sponsored materials than in those that do not use NSF materials.

3. Activities used in teaching science have changed since the late 1950's. There is more use of "hands on" and laboratory type instruction than prior to the NSF material development effort. However, a substantial number of teachers do not emphasize laboratory activities. Lecture-discussion is the most common learning activity, followed by student demonstration. Reports and surveys indicate a substantial number of teachers (probably about 30-40%)teach science largely as a reading/lecture class.

4. There has been an increase in the use of educational television and films. Data indicate the use is highest in the lower grades.

5. Procedures for identifying students with special interest and aptitude are used by many schools. About 20% of the schools report special classes or programs for teachers.

6. Equipment available for teaching science has been increased in a

number of schools--largely due to NDEA funds.

Barriers to effective teaching have been of interest to science educators for a considerable period of time. Research studies have been done to identify what people believe are barriers, what others believe barriers to be, what correlates with practice, and what tends to be identified from experimental studies and observations

Blackwood (1965a, 1965b) identified several potential barriers to effective science teaching from a review of literature and asked principals to indicate the extent to which they felt these items hindered good science teaching. Each of the following items was rated as an important barrier by over 60% of the respondents.

1. Lack of consultant services
2. Lack of supplies
3. Lack of room facilities
4. Insufficient funds
5. Lack sufficient knowledge
6. Lack inservice opportunities
7. Teachers can not improvise
8. Teachers not familiar with methods

In 1970-71 a team of investigators at Ohio State surveyed a national sample of teachers and found similar results. A replication of parts of the study in 1972, 1973 and 1974 (Howe,1977) reflect substantiallv the same barriers with slight shifts in percentages of responses.

Correlational and experimental studies suggest that when these barriers are removed or reduced the pattern of teaching is different. (Steiner et al, 1974; Anderson and Horn, 1972; Berger, 1973; Blosser and Howe, 1969b; Southerland, 1972).

Instruction can be improved if efforts are made to focus on the barriers. It would appear that insufficient effort has been provided to reduce these persistent barriers.

A considerable number of research studies have focused on whether different types of instruction make a difference and, if so, what difference, in student learning outcomes. Reviews by Belanger (1969), Ramsey and Howe (1969a), Ramsey and Howe (1969b), Shulman and Tamir (1973), Bredderman (1977) and others indicate the type of instruction does impact on student learning.

Secondary School Science

With the exception of Rogers'(1967) survey of practices in junior high schools, no large surveys were conducted on secondary school science practices in the late 1950's and 1960's. Hence, comparisons will be made to data found in many individual studies of one or more states. Data from The Ohio State studies provide information for early 1970's. Individual studies and replication of selected aspects of the Ohio State studies in 1972, 1973, and 1974 provide further data.

These data indicate the following:

1. There is an increase in the use of student centered activity (less lecture); however, lecture discussion is the predominant method used by teachers.

2. About half the schools report grouping students for science instruction. This appears to be most frequent in grades 7, 8, 9, and 10. Courses at grades 11 and 12 tend to be elective.

Certain courses, primarily chemistry and physics, are self selective the way they are currently taught. Research studies by a number of people including Young (1965), Van Koevering (1971), Welch (1969), Bridgham (1973) and others indicate the type of students who select physics tend to be a consistent subset of students with essentially above average I.Q., interests in mathematics and science, and often career interests that will use science. Reasons for not selecting physics frequently are due to the

lack of the above factors and from fear of low grades. Chemistry tends to suffer from the same image, but to a lesser extent. If enrollments are to be increased in these content areas, different approaches to the courses are needed; some schools have developed different offerings to appeal to more students.

3. Schools have become better equipped for science instruction. Federal funds have been used by over 50% of the schools to augment their equipment. While most of it is used, the extent to which it is used varies widely.

4. Average and below average students have had difficulty with a number of the NSF sponsored materials. Data suggest this was due to high reading level and difficulty of some of the concepts.

5. While some efforts have been made to develop and use individualized and self-paced instruction (for example ISCS), a very small number of students are exposed to these types of instruction.

6. Use of educational television and computers is increasing. A number of schools have purchased or leased a minicomputer while others rely on rented time. While educational television is being used, the extent to which it is being used is very limited. Television and individualized learning materials offer two promising ways of improving instruction and also reducing instructional costs since both can reduce expenses related to staff and facilities.

7. The number of alternative materials for teaching science has increased markedly since 1955. The variety of materials that are available place a greater burden on the local school regarding selection and articulation.

A number of investigators have surveyed teachers and administrators and have conducted other research studies to identify correlates of <u>effective instruction</u> and <u>good programs</u>. Schlessinger et al., (1973) identified a number of variables believed to be very important by 50% or more of a

national sample of teachers. These were:

1. Science facilities
2. Administrative support
3. Staff cooperation
4. Small classes
5. The number of separate subject preparations-reasonable
6. Good instructional materials

Felt to be important, but less important than the previous were: (a) Teaching loads (b) In-service Education (c) Salary.

Other studies tend to agree with these variables as being important. Research on the change process also supports these same variables as being important for implementing and maintaining programs. The main variables identified are key personnel, administrative and peer support, usable materials, help in implementation, and incentives to the persons involved in the change process.

Research on whether instruction makes a difference at the secondary school level has been reviewed by Ramsey and Howe (1969b), Shulman and Tamir (1973), and others. The data indicate certain instructional modes are more effective for certain groups of students and specific objectives.

The data also indicate the teacher in usual instructional patterns is the most important instructional variable. In individualized approaches, materials tend to become more important.

About 50 percent of the students in secondary schools currently complete their last course in science in grade 10 (Schlessinger et al., 1973; White et al., 1974; NCES, 1974, 1975, 1976; 24 state reports). Thus, there is little science emphasis in the curriculum of a large percentage of the students. While the merits of various materials and approaches for teaching science can be considered, there will be virtually no impact

of these on many students during their last two years in high school.

For many students the last physical science course completed is in the ninth grade. Thus, these students have little or no contact with physical science concepts, methodology, and applications during their last three years of secondary school.

A review of state requirements (as of 1976) course enrollments from state and national reports, and current reports of various groups regarding educational needs indicate science courses are usually required in only one or two years of the four year high school program. In the opinion of the reviewers, it appears that the role of science in the secondary school curriculum for general education remains unclear. What science students should learn also remains unclear.

Facilities and Equipment

In the bulletin "Conditions for Good Science Teaching in Secondary Schools", produced by NSTA, the case for science resources is stated:

> It is now widely recognized that science is a process and an activity fully as much as it is an organized body of knowledge and that, therefore, it cannot be learned in any deep and meaningful way by reading and discussion alone. (1970, p 3.)

The literature indicates that the adequacy and availability of science facilities, equipment and supplies is as important at the elementary level as at the secondary level.

The following statements summarize conditions with respect to science facilities and equipment:

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1. Adequacy of science facilities is perceived as one of the most important conditions necessary to a good science program.
2. Science equipment and supplies, or their perceived lack, greatly influence the teaching of science.
3. Availability of funds for purchasing equipment and supplies is a major factor in the science program.
4. Flexibility in usage is increasingly important in science laboratories and facilities.

There is widespread agreement in the literature about the importance of science laboratories and facilities to the science program. Based upon surveys of 850 schools in 7 states, Koelsche and Solberg (1959) reported that about half the schools indicated they lacked adequate laboratory space. About one-third of the schools had inadequate storage space.

Schlessinger et al. (1973), in a summary analysis of surveys by Chin (1971), Baker (1973), and Buckeridge (1973) compiling data on a national basis, reported that of 2,254 secondary school science teachers of a national sample responding to a questionnaire, nearly 94% rated science facilities

in the two highest categories of important factors for a quality science program. Approximately 90% of the secondary schools science teachers reported having a laboratory or special science room available.

Rogers reported in 1967 that about seven out of ten junior high schools had a combination laboratory-classroom and one out of ten had separate laboratory-classroom arrangements. More than 25% had no laboratory facilities.

At the elementary school level, Blackwood (1965) reported that inadequate room facilities was ranked second when rating the extent of difficulty of 13 barriers to teaching science. Similar findings were reported by Maben (1971), Webb (1972), and Nelson (1973) in a series of related surveys of elementary school science. Each of the three studies sampled defined regions of the U. S. such that the combined studies yielded results on a national basis. In all of the studies inadequate room facilities was considered the greatest barrier to teaching science.

As a function of adequate facilities, sufficient space for preparation, storage, and student activity is a critical condition (Conditions..., 1970). A basic assumption underlying nearly all studies of science facilities is that teaching facilities should be derived from and supportive of a specific curriculum (Hurd and Rowe, 1964). It seems clear that attempting to teach science in a regular classroom, without modifying it in some appropriate way, is not likely to be effective.

Secondary schools reported having an annual budget for science equipment and supplies in about 64% and 76% of the cases, respectively. Most common budgets reported were from one to three dollars per pupil per year (Schlessinger et al., 1973).

According to Rogers (1967), junior high schools fared less well with about 70 percent of the schools reporting budgets for science equipment and

supplies. Almost 20 percent of the schools did not provide for either new equipment or consumable materials in the annual budget. The mean expenditure per school for the nation was approximately $800 but the median was $494.

Again, at the elementary school level the data reported present a negative image. Blackwood (1965) notes that 46% of the schools reported that science equipment and supplies were inadequate or completely lacking. This lack of equipment and supplies was ranked second in difficulty as a barrier to teaching science at the elementary school level. The annual expenditure for science equipment and supplies reported by most public elementary schools ranged from 11 to 14 cents per pupil. By 1970-71, conditions had improved somewhat. Annual budgets for science equipment and supplies were reported for about 50% of the elementary schools. Lack of supplies and science equipment was ranked the second greatest barrier to teaching science in all three studies (Maben, 1971; Webb, 1972; Nelson, 1973).

Lack of supplies and equipment implies a funding problem, of course. Although the majority of the secondary schools reported an annual budget for equipment and supplies, NDEA funds were used for purchasing science equipment by about 69% of the schools and for purchasing supplies by about 43%. In addition, 15% of the schools reported using NDEA funds for remodeling science facilities (Schlessinger et al., 1973).

At the junior high school level, Rogers (1967) reported that over 80% of the schools used NDEA funds to purchase science equipment and approximately one third used NDEA funds for remodeling.

The use of NDEA funds for science equipment and supplies was reported by about 66% of the elementary schools. Remodeling of facilities, using NDEA funds was reported for about 15% of the elementary schools (Maben, 1971; Webb, 1972; Nelson, 1973).

Piltz and Steidle (1966b) also report that many schools throughout the 50 states used NDEA funds for the purchase of supplies and equipment as well as for remodeling science facilities. A majority of the states reported that the use of these funds had a significant impact on their science education programs.

Considering the existing lack of science equipment and supplies, and the absence of sufficient funds for purchasing, any alteration in federal funding would clearly impact on the science program. This would be particularly great at the elementary and junior high school levels, in the first instance because existing budgets are so low, and in the second because of the high use of federal funds.

Finally, while adequacy of science facilities is critical to an effective progam, increasing attention must be paid to the flexibility of such facilities. Reviewing the results of the study by Novak (1972) together with the recommendations by NSTA (Conditions..., 1970), makes it clear that science facilities must be able to accomodate large group instruction, small group instruction, individual studies, long term projects, group laboratory activities, modular scheduling as well as a variety of other instructional arrangements. A single room with fixed tables obviously will not serve. As Richardson (1961) recommended, the requirements for the design of a science facility should be based upon an analysis of the course content and the classroom activities which the facility is to serve.

III. SCIENCE TEACHER EDUCATION

The materials reviewed for this section were obtained by searching the ERIC data base and by contacting state departments of education for literature related to teacher certification standards. The documents may be broadly categorized as descriptive information research studies, research reviews, bibliographies, and state of the art papers. While some are concerned with science teacher education in general, the majority can be categorized as dealing with either preservice education or inservice education. A few papers focus on relating preservice education to in-service activities and stress cooperative efforts of colleges or universities and public school systems.

In addition, two sets of Guidelines, developed by the National Association of State Directors of Teacher Education and Certification (NASDTEC) and the American Association for the Advancement of Science (AAAS) for the preparation of elementary school teachers and for the preparation of secondary school teachers of science and mathematics are included in this report. The set of guidelines, published in 1967 by the Association for the Education of Teachers in Science (AETS) which focuses on the professional education experiences for science teachers is also reviewed.

PRESERVICE SCIENCE TEACHER EDUCATION

Information contained in this section relates to certification standards as these were identified from state materials, broad guidelines for teacher preparation as proposed by the NASDTEC-AAAS groups, a collection of some promising practices in science teacher education, and findings from research investigations focused on preservice teacher education programs and students.

Preservice Teacher Education: Guidelines

The following statements appear to hold true for the documents reviewed for this section of the report.

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1. These materials have been developed to provide a base for action which may be used by state certification officials in developing certification criteria.

2. The documents may also be of use by education faculties when developing or modifying programs.

3. Concern in the early 1960's was focused on subject matter competence of teachers. Emphasis was placed on breadth and depth in the sciences, with sufficient preparation to enable the teacher to do graduate work in science.

4. As times changed, guidelines were revised. Content competency was still stressed but additional emphases were added to the guidelines (e.g., humanism, ability to communicate).

5. Some attention was given to the experiences that should form part of the professional education component of a teacher preparation program in science. The guidelines which resulted have yet to be fully, or widely, implemented.

6. If guidelines and standards are to be implemented, they must be clearly communicated. Specificity in language is needed; descriptions of exemplary applications are desirable.

7. Guidelines which can easily be translated into a course or series of courses are easiest to implement or most likely to be implemented.

Because state certification standards are more explicit concerning criteria for secondary school science teaching, this section will focus on the NASDTEC-AAAS guidelines for secondary science and mathematics teacher preparation. The 1961 guidelines resulted from work begun in 1959 and were based on four conferences, held in different geographical locations and involving representatives from the sciences, mathematics, and teacher education (1961 Guidelines, p.iv). The conference participants focused on the content preparation of preservice teachers and not on the general and professional education components of undergraduate teacher preparation programs.

The developers of the Guidelines hoped the documents would be of use to state directors of teacher education and certification as they were concerned with providing adequately prepared teachers for the public schools (1961 Guidelines, p.2). Eight guidelines were held to be common to all science subject fields and to mathematics.

I. The program should include a thorough, college-level study of the aspects of the subject that are included in the high school curriculum.

II. The program should take into account the sequential nature of the subject to be taught, and in particular should provide the prospective teacher with an understanding of the aspects of the subject which his students will meet in subsequent courses.

III. The program should include a major in the subject to be taught, with courses chosen for their relevance to the high school curriculum.

IV. The major should include work in areas related to the subject to be taught.

VII. The program should include preparation in the methods especially appropriate to the subject to be taught.

VIII. The program should take into account the recommendations for curriculum improvement currently being made by various national groups.

(1961 Guidelines, pp.5-6)

Hausman (mimeo. paper, p.1) reports that the 1961 guidelines were rapidly accepted. He speculates that this was due, at least in part, to the mood of the times: the country's concern, after Sputnik, for upgrading the public schools. In addition, the National Science Foundation provided a large amount of assistance through its funding of teacher institutes and of content improvement projects. The National Council for Accreditation of Teacher Education (NCATE) provided an additional impetus for change by asking institutions seeking accreditation for their teacher education programs to show how they were using guidelines recommended by the academic professions (Hausman, p.2).

Related to but preceding the 1971 NASDTEC-AAAS Guidelines is another set prepared by several science educators who served as a Joint Teacher Education Subcommittee linking the Cooperative Committee on the Teaching of Science and Mathematics, American Association for the Advancement of Science, and the Association for the Education of Teachers in Science (AETS) (Taylor, 1967). This set of guidelines was focused on the professional education sequence for prospective science teachers. The document advocated that four general areas in preservice education programs should be identifiable: (1) the school as a social institution, (2) characteristics of learners and the conditions of learning, (3) understanding teaching methodology, and (4) practicum type experiences (Taylor, pp.7-8).

The manner in which the professional education experiences were implemented in a teacher preparation program was not specified. However, three possible approaches (traditional, functional, and competency) were suggested (Taylor, pp.8-11).

During the decade of the 1960's, the climate in the schools changed. A revision of the 1961 NASDTEC-AAAS guidelines seemed appropriate. In the 1971 document, the number of guidelines was increased to twelve. They will not be produced in their entirety here but will be identified as to areas of concern: (1) humaneness, (2) societal issues, (3) nature of science and mathematics, (4) science competencies, (5) mathematics for science teachers, (6) basic mathematics competencies, (7) algorithms and computing, (8) modeling in science and mathematics, (9) communication of science and mathematics, (10) learning conditions, (11) materials and strategies for teaching, and (12) continuous learning.

The increase in number of guidelines was not the only change. The 1971 document was considerably different from that of 1961. Hausman has described the 1971 version as follows:

> . . . Instead of focusing on the content of academic courses needed to teach a specific high school subject, the new Guidelines reflect a broad philosophical outlook on the nature of science and math teaching in modern contexts. It speaks both to the competencies required of the teacher, with samples of how these competencies might appear in practice, and the desirable personal characteristics that should be developed in a teacher. Without overlooking the basic subject matter requirements, the Guidelines remind the reader that teacher preparation is rooted in liberal education. They then point up the need to include experiences that foster humaneness, familiarity with societal issues associated with science and technology, the intellectual and philosophical nature of science and mathematics, continued learning and communication of new ideas, and the like . . . .(Hausman, p.2a)

Because the 1971 Guidelines were concerned with more than content proficiency, their impact is less easy to assess. Nevertheless, the intent of the document was to provide a basis for action. Hausman has attempted to assess what, if any, action has been taken. His data were obtained through the use of a survey questionnaire sent to institutions

from which 50-100 science teachers had graduated in a three year period. Using a questionnaire which dealt with nine of the guidelines (6,7, and 8 were omitted), Hausman surveyed 89 institutions. Sixty-seven usable returns were received (Hausman, pp.4-5).

Three guidelines showed a high degree of implementation: IV, involving breadth and depth in science content preparation; V, involving minimal mathematics competencies for science teachers; and X, stressing the nature of learning and its application to science teaching. These three guidelines focus on course requirements and relate to the 1961 version which was widely accepted.

Guideline IX, stressing the seeking out of ideas in science new to the prospective teacher's experience and communicating them to others, appeared to be the least successful in implementation. Guidelines II and III, societal issues and the intellectual and philosophical foundations of science, were also rated as hard to implement (Hausman, p.6).

In addition to seeking information regarding the degree of implementation of the Guidelines, Hausman asked his respondents:

> How useful do the 1971 Guidelines seem to be for your institution?
> How useful were the 1961 Guidelines?
> What are your suggestions on the Guidelines and Standards published in 1971? (Hausman, p.5)

These questions produced mixed responses ranging from "high enthusiasm to caustically critical as too idealistic for the real world" (Hausman, p.17). The Guidelines were seen as useful but more specificity was desired (Hausman, p.18).

Hausman also contacted state certification officials. He asked them to supply dates for certification criteria most recently established, to indicate whether the 1971 Guidelines had contributed to these criteria,

and to identify to what extent the 1971 Guidelines had been disseminated and discussed. Only 27 replies were received and only 22 individuals specifically answered Hausman's questions. Relative to the influence of the 1971 Guidelines on certification criteria, 4 reported there had been a great influence, 6-some influence, 2-very little influence, and 10-no influence. In terms of dissemination and discussion of the 1971 Guidelines, 8 officials reported extensive activity, 7-some activity, and 9-very little activity (Hausman, p.23).

In the summary section of his paper, Hausman provided these conclusions:

> The Guidelines are not all equally adaptable to implementation. Easiest are those which can be accomplished simply through course requirements. Hardest are those requiring interdisciplinary thinking, especially when that crosses over the science line into societal concerns. The results indicate that heavy responsibilities are assigned to the educational methods courses in developing desirable personal qualities, instructional techniques, and motivation to continue as a learner. Little evidence is provided for an integration of subject matter and instructional quality in the development of prospective teachers, with the entire faculty devoted to turning out a well-rounded individual. On the other hand, there is considerable use of competency-based teacher education, one of the strong recommendations of the Guidelines. (Hausman, p.28)

In 1973, the president of the Association for the Education of Teachers in Science appointed an ad hoc committee, named the Professional Sequence Committee, to study the need for revision of the 1967 guidelines for the professional sequence for prospective science teachers (Taylor, 1967). Sessions at the AETS fall regional meetings were to focus on this document. Only a few such sessions were held. Feedback from these few sessions and from a relatively small number of individual AETS members indicated the feeling that the 1967 guidelines had not yet been adequately implemented and, because of this lack, there was little basis for suggesting change. Persons from institutions at which competency-based programs had been mandated expressed concern for more emphasis

on the competency approach suggested in the 1967 document but these individuals did not constitute a majority of the respondents. Funds were not allocated for a systematic, national survey of AETS members. Based on lack of feedback advocating change, no action was taken by the Professional Sequence Committee and the 1967 document remains as the official AETS position on desirable professional education experiences for preservice science teachers (Blosser, May, 1974, pp. 26-27).

Both the 1971 NASDTEC-AAAS Guidelines and the 1967 AETS guidelines for the professional experience component of teacher preparation programs reflect concern for preparing science teachers who are more than authoritative sources of science information. Prospective science teachers need to be proficient in science content and to have some amount of breadth as well as depth, but they also need to be able to function as liberally educated humane individuals who serve as desirable models for their students. The next section of this report will focus on the translation of these concerns into state certification standards, if this translation has in fact taken place.

Preservice Teacher Education: Certification

Specific information concerning teacher certification requirements from 12 states was reviewed. Those states were Arizona, Colorado, Idaho, Indiana, Kansas, Kentucky, Maryland, Minnesota, Nevada, Oregon, Virginia, and Wisconsin. Based on these materials and related reading, the following generalizations can be made.

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1. Certification is still basically a function of each individual state.

2. Within a state, certification is based primarily on the "approved program" approach which involves colleges and universities in the certification process.

3. Most states extend reciprocity to persons certified in other states, provided their certification was part of an approved program of teacher education.

4. Elementary teacher candidates are seldom required to take more science content than that required for the general education component of their undergraduate program.

5. Certification for teaching science in the secondary grades usually involves the completion of 24-36 semester hours of science.

6. Changes in science education courses and materials for the elementary and secondary school levels appear to have made little, if any, impact on college course requirements for certification.

7. Certification patterns still are based largely on courses completed rather than upon classroom performance, despite the increase in articles emphasizing CBTE/PBTE.

Most of the bulletins and brochures from the 12 states were similar in that the various states issue one type of certificate upon completion of a baccalaureate program which lasts for a several year period (for Kentucky, 1976, the time involved is 10 years). This basic or provisional certificate (terminology varies with the state) may be renewed upon

completion of several years of successful teaching experience or may be exchanged for a standard, or more permanent, certificate if the certificate-holder is able to present evidence of additional academic work or inservice credit. Most state boards of education recognize that teachers may need to take courses which do not provide graduate credit, and none of the documents reviewed specified that all of the additional course work needed to be in the area of certification. While such flexibility is desirable, there is no necessity that a science teacher gain increased depth or breadth in science content in order to move to the next level of certification.

Rather than listing specific courses to be checked for on a student's transcript, most state departments of teacher education and certification have moved to share some of the responsibility with colleges and universities through the "approved program" approach. Each institution preparing teachers works within the broad framework specified for teacher certification within the state to develop a program which can be approved as meeting the criteria or objectives specified by the state. Certification may not involve sending students' transcripts to the state certification group but may involve only listing the students' names and the areas for which they are to be certified. While this allows the faculty within a given institution to design a program in teacher education that meets the needs of its student clientele, it also makes the institution, rather than the state, responsible for deciding if an individual should be recommended for certification. The brochure from one state (Maryland 1975) contains the information that state standards are minimal and that local systems may establish higher standards for certification.

Reciprocity apparently became an issue when the American population became a more mobile one. Some states, such as Arizona, do not extend reciprocity to teachers with out-of-state certification. Instead, Arizona (1976) requires that both elementary and secondary teachers have a course in reading and practicum and that they be able to pass an examination on the United States and Arizona constitutions. Other state certification brochures (e.g. Kentucky, Wisconsin, Idaho) specify that reciprocity will be extended to graduates of teacher education programs approved by the National Council for Accreditation of Teacher Education (NCATE) or of those institutions participating in the Interstate Certification Project.

Because NCATE is a national voluntary accrediting agency for the accreditation of teacher education institutions, not all programs are submitted to this approval process. A brochure from Virginia (1976) identified approval as being NCATE, regional, or "other."

When materials are surveyed relative to the science preparation of prospective elementary teachers, the fact that the last several decades have seen science curriculum improvement projects developed for the elementary schools as well as for high school science has had little apparent impact on certification standards. The content requirements appear to be little changed over the years. The emphasis on teaching reading and communication skills remains a strong one. Some states (Arizona, 1976; Kansas, 1975; Kentucky, 1976; Maryland, 1975) specifically state that a certain number of science courses or hours of science must be a part of the preservice teacher's undergraduate program. For other states, such as Indiana (1969), science is listed as a part of the general education component of the student's undergraduate program.

Science courses taken to fulfill a general education requirement are likely to be of the survey type or a relatively basic introduction to a particular branch of science. These courses are not likely to contain an emphasis on science process skills stressed in some of the elementary science course improvement projects. It is assumed that exposure to science processes and the inquiry approach to teaching science will result if the student enrolls in a science methods course. Not all state brochures identified a science methods course as a required part of the professional education component of a baccalaureate teacher education program.

An educational bulletin from the Kentucky Department of Education (1957) was focused on an effort to improve science teaching in the classrooms and science preparation of teachers. The Superintendent of Public Instruction proudly reported, in December, 1957, that Kentucky had received the first grant in the nation made to a state department of education from the National Science Foundation and the first grant for elementary teachers. This grant funded five regional conferences (two days long) at which persons from teacher preparation institutions and local school systems met to plan a continuing program of science teaching improvement. Nevertheless, Kentucky certification standards (1976, p.46), while requiring 12 hours of mathematics and science for elementary school teachers, place more emphasis on mathematics than on science.

This lack of congruity between goals and practices may be explained by quoting from a position paper on Michigan science education (1975). The members of the Michigan Science Education Referent Committee,

composed of college science educators, curriculum consultants and supervisors, inservice teachers and administrators, explain that worthy goals are not implemented because

> . . . boards of education, school administrators, teachers, and lay persons find it extremely difficult, if not impossible, to conceptulize and appreciate the completeness of this set of goals, when all about them they hear the din of admonitions to improve reading and arithmetic scores only (1975,p.2).

Although science content requirements for elementary school teachers appear little changed over the years, a different situation exists for secondary science teacher preparation. After Sputnik, science content requirements, for most state certification programs, increased. This reversed a previous trend in which the number of credits for professional education courses frequently exceeded that of content hours required for teaching a subject (Stinnett, 1971, p.25). The table, below, provides data for 1970.

TABLE 5

BASIC REQUIREMENTS AMONG THE STATES IN 1970 FOR AUTHORIZATION TO TEACH THE SCIENCE FIELDS AND SUBJECTS, IN SEMESTER HOURS

FIELD OR SUBJECT	MEDIAN REQUIREMENTS	RANGE IN REQUIREMENTS	NO. OF STATES WITH MINIMUM HOURS SPECIFIED*
Science	30	15-54	34
General Science	24	15-48	35
Physical Science	24	8-42	25
Biological Science	24	15-42	27
Chemistry	30	12-36	41
Physics	24	10-42	41
Biology	24	8-44	40

*The remaining states specified majors or minors or approved curriculum.

Source: T. M. Stinnett. A Manual on Certification Requirements for School Personnel in the United States (1970 Edition). National Commission on Teacher Education and Professional Standards, National Education Association, Washington, D.C.: The Association. Adapted from Table 4, p.54.

Certification requirements for secondary school science teachers vary from state to state and are difficult to compare since different institutions place different interpretations on the courses which students should take to meet the state standards in terms of credit hours. A committee in Wisconsin has expressed concern that that state's certification standards for secondary school science teachers do not adequately reflect changes that have taken place in the science curriculum. In a proposal to the State Superintendent's Advisory Committee for Teacher Education and Certification (March 6, 1976) the committee suggested several changes in science certification. The establishment of a new certification category, broad field science, was advocated as was the elimination of the certification categories of science-all, general science, astronomy, physiology, and geology.

Such a change would result in certification in broad field science, biology (life science), chemistry, earth science, physics, and physical science. The committee provided a rationale for these changes, pointing out the fact that

> . . .substantial changes have taken place in the science curriculum of the junior and senior high schools. General science, as it was understood at that time, has virtually disappeared from the curriculum. In the contemporary junior high school a diversity of broad introductory courses in a specific area of science as well as courses drawing significantly from the several science disciplines may be found. At the senior high school level the specific courses in biology, chemistry, earth science and physics continue, but here too a number of courses which do not fit neatly into these categories have become a regular part of the curriculum. . . .Furthermore, all of these programs involve a heavy emphasis on student involvement in science as an investigative process. Clearly the teachers of these science courses at the junior and senior high school levels need a breadth and depth of preparation in science which is not reflected in the current certification standards (1976,p.5).

The next section of this report contains an examination of some representative programs in science teacher education, in an attempt to identify the influence of guidelines statements and certification standards as these are translated into program descriptions.

Preservice Teacher Education: Programs

The documents analyzed relative to this section of the report may be classified relative to their source of publication. Many are articles published in professional journals. Others come from an AETS-ERIC publication entitled "In Search of Promising Practices in Science Teacher Education," (Roberts et al., 1973). Related program descriptions are found in another ERIC Publication, "Secondary School Science Teacher Education: Where Are We Going?" (Schaff and Voss, 1974). This document resulted from a joint National Association for Research in Science Teaching (NARST)-Association for the Education of Teachers in Science (AETS) panel presentation at the March, 1974, NARST meeting. While the "Promising Practices" document reports on program descriptions presented within the constraints of a schema developed by a member of the AETS Publications Committee, the "Where Are We Going?" document allows science educators from various institutions to speculate about future directions for their own programs and for science teacher education in general.

Research related to the preparation of elementary teachers to teach science and to the preparation of secondary school science teachers will be discussed in a later section of this report.

Based on the materials reviewed for this section, the following generalizations appear to hold true.

1. Modifications in existing programs provide for more attention to process skill development for elementary teachers.

2. Changes reported in teacher education programs in science involve the inclusion of such topics as humanism, relating science to contemporary social problems and issues, extended field-based experiences, and involvement with inner-city students and other minority groups.

3. The funding of nine model teacher education programs by USOE focused on elementary teacher education appears to have had little impact on science teacher education other than at the institutions housing these programs.

4. Some institutions are involved in competency or performance based teacher education programs. This has occurred either because personnel at an institution are anticipating a change toward this approach or have been mandated to make the change.

5. Additional program development and modification activities took place in science teacher education because funds were available through the Undergraduate Preservice Teacher Education Program (UPSTEP) project of the National Science Foundation.

6. Programs designed to prepare teachers to work with junior high or middle school pupils are few in number.

The writers of Chapter 14 in the fifty-ninth yearbook of the National Society for the Study of Education, Rethinking Science Education, (Henry, ed.,1960) were concerned that elementary teachers should use science content to promote the optimum growth of the child (p.260). They urged that children be involved in investigatory experiences in the laboratory and in the field. They also emphasized that science courses for elementary teachers should stress such activities so that prospective teachers would be provided with desirable models in the hope that they would teach as they were taught (p.261). They also advocated that prospective elementary teachers needed to have science content courses

beyond those recommended as a part of a general education program for all students (p.262). Some of the program descriptions published in In Search of Promising Practices in Science Teacher Education (Roberts et al., 1973) provide evidence that these concerns have been translated into program elements.

Those science educators who work with prospective elementary teachers are still concerned with the task of preparing teachers to use modern science curricula effectively. The usual technique used in college science classes is that of lecture and laboratory (usually for verification, seldom for discovery) which does not provide the necessary cognitive and affective skill development elementary teachers need (Kuhn, 1973). One solution to this problem may lie in the approach used at Purdue (Nordland and DeVito, 1974). In this program, faculty members work with the same students for six semesters (three years). Continuity is also provided by a central theme: Man and His Environment, as related to Survival in the Face of Change and by the pervasive questions: How do I know? Why do I believe? What is the evidence?

Prospective elementary teachers enroll in the science methods course first and then take science courses (two biology courses, a combined two-semester physics/chemistry course, and an applied outdoor environmental studies course). Ideas are emphasized first and then vocabulary. Because students are allowed time to solve problems as they learn science, course content is reduced by 90 percent (Nordland and DeVito, p.386).

An additional idea for improving elementary teacher preparation in science is that of having two separate science methods courses; one aimed at primary grades and another for intermediate grades (DeVito and Krockover, 1974). Results of some informal research completed by the authors of this

proposal provide evidence that elementary teacher candidates express a definite preference for a particular grade level. Even if they do not student teach at this grade level, they usually manage to get a teaching position which is at the grade level they prefer. If they are not successful in obtaining the grade preferred, their placement is usually only one grade level different and seldom varies by more than three grades. Because such a preference exists and persists, the primary grades methods course could stress the process skills of observing, classifying, measuring, and inferring. The intermediate grades methods could emphasize controlling experimental variables, formulating hypotheses, interpreting data, and formulating models. If student numbers are not sufficiently large to merit two separate elementary methods courses, the conventional course could be subdivided by individualizing instruction.

Although this is an interesting idea to consider, the primary grades process skills appear to be basic to the development of the skills emphasized at the intermediate grade levels. Children progressing through a process-centered approach to elementary science should possess these basic skills. However, it would seem that their teachers should also have had experiences in use of the basic process skills in order to be able to correctly design activities focused on development of the more complex process skills.

While science educators working with elementary teachers are concerned about promoting a process oriented, hands-on approach to science, those science educators who work in secondary teacher preparation programs appear to be equally concerned about translating science content into student-centered activities (Roberts et al,1973). However, they are also concerned

with providing more field-based experiences for prospective teachers and for acquainting these individuals with a variety of student groups. Preparing science teachers to work in inner-city settings appears to be a common concern in many secondary education programs (Roberts et al.,1973; Turner et al.,1974; Massey and Eschenbacher, 1972). The program which Turner and his colleagues describe emphasizes the selection process for the candidates. This differs from the more customary approach to the selection process, that of allowing students to participate in a variety of activities with inner-city students and, through these experiences, to decide if they want to work in an inner-city school as an inservice teacher (Massey and Eschenbacher; Howe in Roberts et al.,1973,pp.186-193).

In 1967 the U. S. Office of Education issued a call for proposals involving the development of comprehensive undergraduate and inservice teacher education programs for elementary teachers. "Elementary" was defined to include the range from preschool through grade eight. Nine of the proposals received were funded. The institutions which were involved were Florida State University, Michigan State University, Syracuse University, Teachers College - Columbia University, The University of Georgia, The University of Toledo, University of Pittsburgh, University of Massachusetts, and the Northwest Regional Educational Laboratory. A search and review of the science education literature related to program descriptions did not reveal any noticeable impact of these model programs on elementary science teacher education.

In a publication which describes science courses for elementary education majors at the University of Georgia, one of the model program institutions, the editors attribute the start of competency-based teacher education to the nine model programs although they conclude ". . .the earliest forces

energizing the competency-based teacher education movement are obscure in educational history" (Capie and Markle, 1974,p.1). The concern for competency-based or performance-based teacher education CBTE/PBTE) is evident in some science education literature (Schaff and Voss, 1974; Berger and Roderick, 1975; Roberts et al., 1973, Strassenberg and Paldy, 1974) as well as in general teacher education literature (Aquino, 1976; Houston, 1974; Schmieder, 1974). These citations are representative of the types of materials concerned with CBTE and its related promises and problems.

Advocates of CBTE/PBTE appear to think that programs will benefit because preservice teachers will be placed in classrooms to demonstrate their skills rather than remaining on campus, student progress will be controlled by the student himself rather than by the number of courses completed, competency specification will guide both students and teacher educators. However, Berger and Roderick (1975) discovered, when they attempted to identify competencies for teaching elementary school science that inservice and teacher educators were not in agreement in their ratings, both of the competencies themselves and of the time in a prospective teacher's career when the competencies should be demonstrated.

Strassenberg and Paldy (1974,p.46) point out that college science teachers who are interested in teacher preparation are concerned that the development of CBTE/PBTE programs will mean that non-education faculty members, and their disciplines, will have little influence on the teacher certification process.

Bruce Joyce, in a publication compiled by Schmieder (1974), identifies another potential problem related to CBTE. Joyce states that the production of high-quality software is necessary. If this software is not available, then competency-based certification standards will be created without the capacity to assess adequately or to remedy a deficiency once it is found. Joyce explains that this happens now, when the accountability movement

pressures teachers to show pupil achievement gains but precise training is not provided so that teachers can increase their capacity to produce achievement gains (Joyce, in Schmieder, 1974, p.191).

The National Science Foundation has made funds available for teacher education program development and/or redesign through the Undergraduate Pre-Service Teacher Education Program (UPSTEP). The program, announced in 1969, has received over 200 proposals and has supported 28 projects (McGuire in DeVito, p.2). Reports of UPSTEP activities at the University of Iowa (Lunetta, 1975) and at Purdue (DeVito, no date) provide examples of changes that have resulted in science education programs. The Iowa program has been redesigned so that, while maintaining the distribution of 32 semester hours of general education, 54 semester hours of science, and 26 semester hours of education, education experiences begin in the freshman year and continue throughout the four year program. Because of the continued education activities, there is less intensive student teaching experience during the senior year. However, the Iowa staff believes that the quality of this student teaching experience is increased by the prior activities in which the students participated.

The Purdue UPSTEP program (DeVito, no date) began in the fall of 1972. This program emphasizes a six-semester integrated science-methodology course combined with early and continued elementary school teaching experience. Prospective elementary teachers are involved in experiences consistent with the nature of scientific inquiry (DeVito, no date, pp.7-8). Evaluation data from the program support the hypothesis that the integrated inquiry approach to science promotes greater understanding of the assumptions, activities, objectives and products of science than does the traditional approach

at Purdue (DeVito, no date, p.21). Results of Piagetian-style tasks, administered to the UPSTEP students and to a control group, suggest that curricular materials for which students use concrete materials and problems can promote the development of formal thinking abilities (DeVito, no date, p.26).

Although several states (Indiana, Maryland, Wisconsin for example) do have certification standards for junior high school or middle school teachers (based on materials received), the science education literature does not indicate that colleges and universities have programs specifically designed to prepare science teachers to work with junior high or middle school pupils. A small survey conducted by Mechling (1975) provides information descriptive of this problem. He surveyed 80 junior high school science teachers in western Pennsylvania and found that only four percent indicated they had prepared to teach at this level (Mechling, 1975, p.395). During a 10 year period (1960-61 to 1970-71), one-fifth of the science teachers in Pennsylvania teacher education programs were certified in general science but almost twice as many pupils take junior high school science (usually general science) than are enrolled in all of the specialized science courses in senior high school.

Mechling believes that preparation of teachers for junior high/middle school science teaching has been ignored because of the fallacy of believing that anybody can teach science at either level (junior high, senior high). There is a lack of support for junior high school teacher education from professional science education organizations. It would seem that state departments of education will have to support and encourage colleges to develop such programs by setting certification standards for junior high school science teacher certification.

One document that is an attempt to summarize the then-situation in science teacher education programs is The Research on Science Education Survey (Newton and Watson, 1968), often referred to as the ROSES report. Data were collected by questionnaires mailed to 992 institutions, to be completed by instructors of science methods courses. In addition 37 colleges and universities were visited in a non-random sampling procedure so that information from various sizes and types of schools in different geographical locations could be obtained.

The investigators concluded that course requirements varied considerably among institutions. Student teaching experiences also varied, with the most common plan being full-time teaching for less than a full semester. They cited what they termed three "obvious trends" in science education in 1968: (1) a diversity of programs in science education, (2) lack of basic, objective evidence for effectiveness of teacher education programs, and (3) isolation of science educators from their colleagues at other institutions, which has implications for program development.

Although these trends, and their implied criticisms of science education, may have been valid for 1968, the situation does appear to have improved. Funds from UPSTEP, the development of the nine model elementary teacher education programs, the evidence from programs reported in the journals as well as in special publications (Roberts et al, 1973; Schaff and Voss, 1974) that science education programs are including more field-based experiences for prospective teachers, and a special section on teacher education in the journal Science Education, all serve as evidence that, while more changes may be needed, the picture in 1977 is not so dismal as it was painted in 1968. In addition, data from research conducted on science teacher education also provide hope for continued improvement. Such information will be discussed in the next section of this report.

Preservice Teacher Education: Research

Documents reviewed for this section of the report consisted of doctoral dissertations, journal articles (usually describing dissertation research), reviews of research (both yearly and on special topics), and additional publications (primarily of the type involving research aimed at the evaluation of preservice programs).

These generalizations appear to apply to the materials reviewed.

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1. Very few studies are of a scope that allows for adequate generalizability to large problems in science education.

2. Many studies appear to lack a sound conceptual basis relative to the hypotheses tested or the questions answered. Many also fail to deal with other categories of variables that might be related to the specific variables under investigation.

3. While studies lack rigor, some show that novel training experiences do produce some changes in teacher perceptions of one kind or another. However, there is little indication if these changes are temporary or not. Nor is there any indication of whether actions in classrooms relate to particular sets of attitudes or perceptions. Also, the components in the training programs that might account for these changes are not identified.

4. Studies of teacher attitudes and values do not always include information about whether any correlations exist between the attitudes teachers hold and the way they teach.

5. Research related to teaching skill development, classroom interaction (primarily of the verbal type), and the use of microteaching has increased during the past seven or more years. This increase may be due, in part, to the increased concern for competency-based teacher education.

6. More research has been published relative to secondary science teacher preparation than to the preparation of elementary school teachers to teach science.

7. The number of studies in the area of the the education, characteristics, and behaviors of teachers has increased significantly from 1972 through 1974.

8. When research published in 1974 is considered, studies seem to indicate that effective programs can be developed to teach science process skills to elementary teachers, that this training is likely to influence the way teachers conduct science lessons, that participation in designing and carrying out investigations of their own is likely to be the most important component of such programs, that knowledge of science content is not highly related to the development of process skills, and that teachers in activity-centered programs have more favorable attitudes relative to science.

9. More research, which includes follow-up studies of graduates, needs to be done to determine the effectiveness of science teacher education programs.

10. More research needs to be done if any theory of instruction relative to science teaching is to be developed, at either the elementary or the secondary school level.

Much of the research on preservice science teacher education, regardless of whether it focused on the evaluation of program modifications or on an experimental treatment of some group of preservice students (with or without also looking at their pupils and/or their cooperating teachers), was done by doctoral students. Although this is not primarily intended to serve as a value judgment, it does serve to emphasize the fact that, as doctoral research, the information which resulted relates only to the local situation and does not provide for generalizability. Anderson, who analyzed research in science education published during the 1971 year, attributes both the lack of generalizability and the low quality of most of the research to the fact that many major professors are not actively doing research and therefore do not serve as models (Anderson, R.D., 1973, p. 5).

Criticisms of the quality of research are to be found in most, if not all, of the reviews of research analyzed. Rowe and DeTure report that their

most prominent criticism of studies related to the education, characteristics, and behavior of teachers is that of the lack of a conceptual model (1975, p.49). Herron and his colleagues emphasize the need for better and more detailed reporting of research studies of competency-based teacher education programs (1976, p.45). They also say that researchers in science teacher education appear to be much better at designing programs to modify teacher behavior than they are at showing that this modified behavior results in more learning by pupils (1976, p.43,59).

In a review focused on science teacher behavior, Evans (Balzer et al., 1973, pp.201-204) reported 21 conclusions which he based on a review of 111 studies of science teaching as well as on studies in other content areas. While many of his conclusions were of the negative variety (no change, no significant differences), Evans did report that the use of microteaching and other skill development activities did produce behavior changes although these were not always long-lasting or did not always transfer from the situation in which the skill development was practiced into classroom teaching experiences.

Although the systematic observation of classroom behavior in research on teaching can be found in the literature as early as 1914, in Horn's work at Teachers College ("Distribution of Opportunity for Participation Among Various Pupils in Classroom Recitation"), there has been an increase in science education research focusing on teacher behavior and classroom interaction beginning in the late 50's or early 60's. Some of the increase may be due to the fact that, as science curriculum improvement project materials became more widely available, the use of such materials resulted in program modifications in science methods courses. Doctoral students could complete a dissertation project while helping their faculty evaluate the effectiveness

of these program modifications. NSF funds, for inservice teacher education (to be discussed in a later section of this report) and for UPSTEP projects, also contributed to program changes which could be studied and analyzed. In addition, as concern for competency-based approaches to teacher education spread, it seemed logical to evaluate program changes and also students through the use of microteaching, simulation, classroom observation, and related research techniques. Such studies have produced mixed results. It would appear that skill development is more lasting when preservice students have an opportunity to interact with pupils of the age they plan to teach during the skill development sessions than when they use peers as pupils (Balzer et al.,1973, Herron et al.,1976).

When the numerous NARST-ERIC reviews of research are considered and compared, these documents show that more research has been published that involves secondary science teacher education than that focused on preparing elementary teachers to teach science. When the three most recent reviews in print are analyzed, the increase in studies relating to science teacher education is evident. The 1972 review contains the reports of 30 studies; the 1973 review, 60 studies; and the 1974 review, 87 studies. In earlier reviews, many of the research studies involved NSF programs for inservice teachers (a readily-available topic for a doctoral dissertation).

The more recent reviews contain studies that, while unfortunately still of a local nature, examine teacher edcation relative to instructional methods as well as studies of teacher attitudes, characteristics, and behaviors. In discussing research related to the CBTE/PBTE emphasis, Herron and his co-authors speculate whether the lack of significant and positive results is due to the fact that the competencies being stressed and evaluated are not the right ones or whether teachers ignore their training once they are in

their own classrooms. They also consider the possibility that the effect of the competency training is diluted by the complexities of the classroom to the point where no effects can be observed (Herron et al., 1976, p.59).

Nevertheless, the 1974 research review does contain some findings that are cause for optimism as indicated by the information contained in generalization 8, earlier in this section. Process skill development for elementary teachers is possible and changes do result that are in the directions desired by both the investigators and the program developers.

However, there were very few studies which involved systematic attempts to follow up the graduates of various teacher education programs. Several authors indicated a desire to do so but said that the scattering of these individuals made such investigations impossible or involved costs that prohibited the research.

Smith and Anderson, in introducing the subsection titled "Studies of the Science Teacher" in the "Science" Section of the Encyclopedia of Educational Research (Harris, 1960, p. 1226), wrote "The proper training of a science teacher for elementary, secondary, and junior-college levels is an unresolved and highly controversial issue." This statement is no doubt as true today as it was when they were conducting their review in the late 1950's.

However, lack of resolution to questions and presence of controversy should not deter researchers. Investigators, both of the doctoral student and more established varieties, need to pay attention to the criticisms voiced by the reviewers of research and improve their efforts.

INSERVICE SCIENCE TEACHER EDUCATION

Documents reviewed relating to inservice education of science teachers do not lend themselves readily to a categorization which parallels that used for reviewing the preservice science teacher education literature. For example, professional organizations have not developed specific sets of guidelines for inservice education programs. This may be due in part to the fact that inservice education appears to mean different things to different people, with little agreement concerning its purposes. Perhaps there are no specific guidelines for inservice education that could be appropriate to every situation. The continuing education of experienced teachers may not be generalizable but may be specific to the local setting (Hite and Howey, 1977, p. 7).

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1. Inservice education may be inferred from certification standards based on the criteria which must be met if a teacher is to exchange an initial certification credential to a more permanent one. But this does not hold for all states.

2. Several broad goals of inservice education are identifiable: skill training, acquisition of information, attitude change, general self-improvement.

3. Much inservice education was accomplished through programs funded by the National Science Foundation.

4. In general, NSF institutes and programs have had a beneficial effect on the teacher participants.

5. More work needs to be done to evaluate the effectiveness of inservice education efforts.

6. Elementary school science teaching still appears to be handicapped by deficiencies both in course content and in teaching methodology, as well as by inadequate teaching conditions in the schools.

7. The science teaching profession, as exemplified by secondary school science teachers, appears to be better prepared (decrease in number of teachers without a college degree, large number of NSF institute participants), younger (25 percent of the science teachers sampled in the OSU study had been teaching four years or less), and relatively satisfied with the career chosen.

8. When junior high school science teachers are considered as a separate subgroup of secondary school science teachers, these people (on the whole) lack depth in more than one area of science. Yet many fill general science teaching assignments.

9. Enrollments in general science-type science courses for junior high school students are decreasing. Separate courses in life, earth, and physical sciences are being offered. Junior high school science teachers appear to have their depth in the biological sciences.

10. There are few preparation programs specifically designed to equip teachers for working with junior high school or middle school students. Such programs imply a science background different from that needed for senior high school science teaching, as well as different education courses.

11. Junior high school science teachers are less satisfied with the science curricula available, considering them less relevant to their pupils than they could be. They also express dissatisfaction with teaching conditions in terms of classroom facilities, equipment, and storage space. [Less-than-adequate teaching conditions were evident in Roger's study (1967) and in Lawrenz's study (1974).]

12. Junior high school science teachers need special preparation if they are to help their pupils become aware of the variety of careers in science as well as helping to encourage scientific literacy.

Inservice Education: Certification

Certification standards are related to inservice teacher education in that each state sets certain criteria to be met if a teacher is to exchange an initial teaching certificate for a more permanent one. Titles for such second-level or more permanent certificates vary from state to state. In some, these are referred to as professional certificates. In a few, they are called "life" or unlimited certificates.

Not all states demand additional educational training in order to obtain a more permanent certificate, however. For example, it is possible for teachers in Kentucky and in Wisconsin to convert their initial certification status into a permanent one upon completion of three years of successful teaching experience. Apparently, success is based on being offered a teaching contract and an administrator's signature verifying that the application for permanent certification is valid. In other states (e.g., Arizona, Maryland), completion of 30 semester hours of course work beyond the bachelor's degree, as well as successful teaching experience, is required. Maryland certification regulations indicate that certification personnel recognize that a teacher may need to do further course work at the undergraduate level. The Maryland specification requires only 15 of the 30 semester hours must carry graduate credit.

Inservice Education: Programs, Practices

Although professional organizations have not drawn up guidelines or standards for inservice education, the necessity for inservice programs is not denied. Preservice programs, no matter how field-based or competency-oriented, cannot educate a prospective teacher so thoroughly that the need to have additional opportunities for skill development is eliminated.

Some educators argue that inservice education needs to begin with a new teacher's first days on the job. If any type of inservice activity does occur at this time, it is usually that of orientation to a particular school system, building, and department or grade level. A paper by Howey (Hite and Howey, 1977) contains a quotation by Robert Leight that neatly describes the need for early inservice efforts. Although Leight's comments were made relative to CBTE programs, they apply to non-CBTE programs as well. Leight contends that (CBTE) programs ignore the differences between entry-level proficiency and mastery-level proficiency. He says

> . . .The failure to make this distinction and to assist the teacher to become a master teacher is the most important confusion and shortcoming of teacher education. Teacher educators have brought the candidate to the point where he can enter the classroom with some competence, but the profession pretends that he is an accomplished teacher. Thus he receives the same assignment and treatment as veteran teachers. The result is that the first year of teaching is the greatest scandal in American education. . . . (Leight in Hite and Howey, p.39)

Generally, inservice education activities tend to ignore problems of beginning teachers and concentrate on helping teachers (1) improve or up-date content knowledge, (2) deal with the proliferation of educational hardware, (3) become more aware of information relative to learning and instructional theory, (4) function adequately in relation to new educational tasks, such as mainstreaming, (5) develop some global awareness, and (6) develop interpersonal, humanistic teaching skills.

A survey of the literature in science education, while providing evidence that science educators are aware of the need for inservice activities, is not filled with descriptions of specific programs although some are reported in the Promising Practices document (Roberts et al, 1973). Additional reports are found in journal articles. Many of these, like

doctoral research, are so local in nature that generalization is not possible. Two Occasional Papers were published in 1969, by the ERIC Information Analysis Center for Science, Mathematics and Environmental Education. One of these papers dealt with inservice education for teachers of secondary school science while the other contained reports about inservice education in science for elementary school teachers (Blosser, 1969a, 1969b). The publication concerned with elementary teachers contained 91 references while the paper about secondary teachers listed 120 references. Not all of the citations, in either paper, related to inservice activities in science; some were references to literature about inservice education in general.

In summarizing the 40 studies and reports related to inservice education in science for elementary school teachers, Blosser (1969a, p. 33) identifies four broad goals: (1) skill training, (2) acquisition of information, (3) attitude change, and (4) general self-improvement. The goals of attitude change and of acquisition of information have received the most attention with few documents reporting programs aimed at developing skills (p.34). Many of the programs reviewed appeared to lack a research base for the plan of action followed (p.35).

Materials reviewed for the secondary school level occasional paper were classified into four categories: National Science Foundation institute programs, locally developed programs, cooperative college-school programs, and research and/or evaluative studies (Blosser 1969b, p.28). Blosser considers that more attention needs to be paid to providing inservice activities specifically designed for beginning teachers so that they do not feel isolated. She speculates that, "If isolation sets the context for the orientation of the beginning

teacher, then it is not difficult to understand why many teachers might equate innovation and change with threats to their security and established routines." (1969b, p.29) Although literature exists about the resistance to new ideas and change that exists among school personnel, few science education studies were concerned with this problem (p.30).

Another concern is the lack of a research base for the plan of action involved in many local programs. This lack may result in a program or plan that is not really appropriate because it may treat the symptoms without ever identifying, and dealing with, the cause (1969b, p.30). Additional criticisms or comments related to research studies of inservice education will be discussed in a later section of this report.

Inservice Education: Programs and Practices in the Form of NSF Institutes. Although many studies have been carried out to determine the effectiveness of inservice teacher education as exemplified by National Science Foundation programs, individual studies will not be discussed here. The reader is referred to a paper by Helgeson, entitled "Impact of the National Science Foundation Teacher Institute Program" (1974). The bibliography for this paper, recently updated, contains over 230 entries. Documents reviewed included dissertations and theses, journal articles, reports, papers presented at meetings of professional organizations, and books.

Helgeson reports that much of the material is of a descriptive nature and deals with characteristics of the institute participants, their attitudes, various aspects of the programs, changes in teaching behavior perceived by students of teachers who had participated in institutes or by administrators as well as teachers' self-reports (1974,p.?).

In the summary section of his paper, Helgeson reports, among other things, that

1. institute participants were generally better qualified than were nonapplicants
2. participants were teachers with heavier science teaching loads and who were active in professional and leadership roles and likely to remain in teaching
3. participation in institutes resulted in increasing teachers' content backgrounds
4. changes which occured in teacher behavior tended to be in the direction desired by the institute developers (1974, pp.40-43)

He concludes that" . . while there are areas where data were scant and where results were not definitive, the National Science Foundation Teacher Institute Program appears in general to have been successful in making a significant, positive impact on science education." (1974, p.43)

An interesting companion document to Helgeson's paper is An Investment in Knowledge by Krieghbaum and Rawson (1969). Their book contains a discussion of the first dozen years of the National Science Foundation's involvement in inservice education activities. An additional document that provides a different view of the situation is "The National Science Foundation and Pre-College Science Education: 1950-1975" (1976). This is a report prepared for the Subcommittee on Science, Research, and Technology of the Committee on Science and Technology, U. S. House of Representatives, issued by the Science Policy Research Division of the Congressional Research Service, Library of Congress.

This report was designed to describe and analyze (1) the reasons for NSF involvement in pre-college level education, particularly apart from research, (2) events and issues affecting the growth of the NSF pre-college programs, (3) accomplishments, and (4) evolution of the structure of the pre-college programs to date (1976, p.3). Information on which the report is based came from a review of hearings testimony, NSF publications, and

additional material from public documents. Although critical of some NSF and NSF-related actions, the authors of this report state ". . .the contributions of NSF were impressive in overcoming deficiencies in science education in the post-Sputnik era. . . ." (1976, p.3).

Inservice Education: Research

Many of the documents categorized as research studies of inservice education for science teachers are doctoral dissertations. This is not an unexpected finding. Criticisms of dissertation studies, reported in the section of this report dealing with research on preservice education, hold true for those doctoral studies focused on inservice education: localized rather than generalizable, containing weaknesses in design or sampling techniques, etc. Reports of research about inservice programs were often lacking in sufficient detail to ensure accurate replication, if this should be desired.

In discussing the evaluation of inservice programs, Blosser (1969b, p. 20) identifies several possible inferences: (1) a formally designed evaluative component is not built into all inservice programs, regardless of whether the inservice activities exist by themselves or relative to a curriculum project, (2) materials available at that time (1969) indicate evaluation was in progress, to be reported at a later date, or (3) evaluative data exist but not for public scrutiny.

A more recent comment on the need for evaluation is in the form of a journal article by Welch (1976). Entitled "Evaluating the Impact of National Curriculum Projects," the article emphasizes the need for the systematic study of success in achieving the general goals of the improvement of education for careers in science and the development of scientific literacy (1976, p. 478). Although those goals appear to be aimed at students, teachers need to be educated to structure lessons and activities that promote the development of such goals, so teacher education (preservice, inservice) is implied. Welch reports that no careful study of the

influence of NSF curriculum projects on teacher education has been made (1976, p. 481). There is need also to study the influence of NSF material on teachers and teaching.

Inservice Education: Research on Science Teachers' Behaviors, Characteristics. Although Welch indicates, in his article, that there is a need to study the influence of NSF materials on teachers and teaching, some studies have been reported, not only in journal articles and reports but also in the document entitled A Review of Research on Teacher Behavior (Balzer, et al., 1973). Evans, one of the three authors of this review, analyzed 111 documents about science teacher behavior (50 related to inservice teachers) and included findings related to inservice education among his summary statements (1973, pp. 202-203).

Evans reported that the influence of inservice programs involving use of one of the science curriculum improvement projects resulted in inconsistent findings at the secondary school level. However, at the elementary school level, there generally was an increase in student activity accompanied by an increase in teacher procedural statements (1973, p. 202).

Both the 1970 and 1974 NARST-ERIC Reviews of Research contain posicive findings relative to educating teachers to use curriculum project materials. Trowbridge, et al. concluded that training sessions with specific project materials were necessary to achieve the desired objectives (1972, p. 20). Similar findings resulted with respect to the use of inquiry teaching methods: teachers who had gained specific training through the use of materials, audio-visual techniques, and inservice programs showed significant changes toward inquiry teaching methods (1972, p. 26). Herron, et al. in discussing studies on the education, characteristics and behaviors of

teachers, state that these studies seem to indicate that effective programs can be developed that influence the way teachers conduct science lessons (1976, p. 42).

Although some of the investigations report positive findings about the effectiveness of inservice education activities, there is still the necessity to link preservice and inservice activities so that the transition from student to teacher is less anxiety-laden and to promote continuous assessment. However, inservice education, other than that promoted through NSF programs, does not appear to have been a major concern of science educators and researchers.

Butts and Raun, in a study designed to determine what factors contribute most to teacher attitude change in an inservice program, studied 60 inservice teachers who were learning to use Science: A Process Approach (SAPA) materials (1967). They identified as predictor variables previous course hours in science, years of teaching experience, grade level taught, and the school. They found that years of teaching experience and the school did not appear related to attitude change. Those teachers with few, or no, previous courses in science valued their inservice experiences more than those who had some science background. If lack of a science content background makes elementary school teachers amenable to inservice efforts, there is a large population available as indicated by surveys and status studies discussed in the next section of this paper.

Inservice Education: Research via Status Studies or Surveys. Some of these documents are produced on a regular basis, such as the five year census work of the Research Division of the National Education Association (1972; Graybeal, 1974, 1976). Other reports are issued from time to time,

but not on a regular schedule (Blackwood, 1965a, 1965b; Rogers, 1967; Obourn and Brown, 1963; Mills, 1963). Still others are published in the form of journal articles (Lawrenz, 1974; Stronck, 1974; Mason and Craven, no date). A cluster originates from a national survey conducted at The Ohio State University. The original research was accomplished through a series of doctoral investigations (Chin, 1971; Maben, 1971; Nelson, 1973; Baker, 1973; Buckeridge, 1973; Webb, 1972). The findings from these research projects are presented in a four volume final report, of which volumes 1, 2 and 4 are presently available (Schlessinger, et al., 1973; White et al., 1974; Steiner et al., 1974).

Data obtained by Obourn and Brown (1963) provide a picture of the status of science and mathematics teachers (and teaching) in the United States in 1961. Using a questionnaire, these investigators attempted to determine the total number of science and mathematics teachers as well as their distribution according to teaching load of periods per day, by geographical region, and size and type of school. They identified 103,666 teachers engaged in teaching one or more periods of science (1963, p. 3). School size appeared to be a factor in determining the teaching load, with 22.5 percent of the science teachers having only two or three periods of science a day (1963, p. 6). In addition, 15 percent had only one science class a day and were probably teaching outside their major certification area. Obourn and Brown considered that these people were probably teaching a ninth or tenth grade science class. This class was probably the first laboratory course in science for their pupils, offered at a time when the pupils were establishing interests in careers (1963, p. 8). If these teachers, or a large proportion of them, were teaching outside their area

of major interest and competence, they could no doubt benefit from inservice education in science.

Another survey of science and mathematics teachers, also completed during 1960-61, was an attempt to obtain information about educational and professional backgrounds and of the "operational milieu" of science and mathematics teachers in grades 7 through 12 (Mills, 1963). Using the National Registry compiled by the National Science Teachers Association (NSTA), a study group representing the National Association of State Directors of Teacher Education and Certification (NASDTEC) and the American Association for the Advancement in Science (AAAS) sent questionnaires to a stratified random sample (3,957). They received 3,012 usable questionnaires within the time allotted for response. This NASDTEC-AAAS study was completed for the National Science Foundation.

Some of the nonrespondents were contacted by telephone. Information from these calls appeared to indicate that nonrespondents were likely to have less college preparation, less likely to have a master's degree, less likely to have attended NSF institutes, and taught fewer classes of science or mathematics (Mills, 1963, p. 1).

Ninety percent of the teachers sampled were working in public schools. There were more men than women science teachers. Over 75 percent of the respondents had 10 or more hours of graduate work. However, the largest percentage of teachers with little or no college preparation (undergraduate or post-graduate) in the subjects they were teaching were those whose assignment was either general science or mathematics for grades seven and eight. The general science teachers had the largest number of credits for biology. Nevertheless, one-third had less than nine hours in biology.

Many general science teachers also had less than nine hours in chemistry. Overall, 57 percent of the general science classes were taught by teachers with less than 9 hours in chemistry, 21 percent by teachers with less than 9 hours in chemistry and in biology (Mills, 1963, pp. 8-9). This study also provided data showing that the longer a teacher had been out of undergraduate school, the less likely this person was to take any additional work in his subject (Mills, 1963, p. 10).

The AAAS Guidelines, discussed in an earlier section of this part of the report, advocated that a teacher working in two sciences should have at least 18 semester hours in each science. If this is considered minimal preparation, then 21 percent of the biology classes, 34 percent of the chemistry classes, and 66 percent of the physics classes were taught by inadequately prepared teachers. Less than 40 percent had taken graduate work in the sciences they were teaching (Mills, 1963, pp. 10-11).

Except in mathematics, the opportunity to specialize in a single subject was extremely limited. Data appeared to indicate that teachers (60 percent) working in buildings with less than 1,000 pupils had little chance to specialize (Mills, 1963, p. 11). Thirty percent of all science and mathematics classes were taught by people who spent some, or most, of their teaching day in other subjects (Mills, 1963, p. 7).

Mills termed the population sampled "surprisingly young" (1963, p. 12) and concluded they would be around to influence pupils for some time to come. While many were well or fairly-well educated, the remainder were either those who have had little, if any, college preparation in the subjects they were teaching or had some preparation but not enough. Teachers with little, if any, preparation were probably misassigned. Those with some, but not

enough, preparation present a problem less easily resolved. They cannot go into regular graduate courses or, if they could, such courses may be too narrow or too specialized (Mills, 1963, p. 12). This group could benefit from appropriately designed inservice programs.

The Obourn and Brown (1963) and NASDTEC-AAAS (Mills, 1963) studies focused on secondary school teachers. Conditions in the elementary schools were also investigated. Paul Blackwood (1965a, 1965b) conducted a study to obtain information about procedures, policies, practices, and conditions affecting science teaching in the public elementary schools (1965b). In brief, Blackwood found that (1) different philosophies of science teaching prevail, (2) economic resources, teacher preparation, etc. are related to the status of science teaching, and (3) when respondents were asked to rate 10 selected objectives for teaching science 97 percent considered 7 of the 10 objectives very important or of some importance. The ranking of objectives for teaching elementary school science is shown in Table 6 on the following page. Unfortunately, the objectives considered of least importance are those related to encouraging life long interests, if not careers, in science.

Blackwood reported that the number of schools teaching science to elementary pupils was increasing. The larger the school enrollment, the larger the percent of schools that teach science more than one-half a year (Blackwood, 1965b,pp. 170-180).

Science consultant help was available in less than one-half of the schools. Science textbooks appeared to play a key role in determining what content was studied. In addition, textbooks were reported as being used more often than any other teaching aid (Blackwood, 1965a, p.188). Large school systems were less dependent on a single textbook than were smaller

TABLE 6

Objectives of Teaching Science Rated by Public Elementary Schools According to Importance and Ranked According to Per Cent of Schools Believing Each Objective Very Important: United States,

1961-62

	Very important	Some importance	Little or no importance
1. Help children develop their curiosity and ask what, how, and why questions	87.0	12.0	1.0
2. Help children learn (how) to think critically	85.2	14.3	5.0
3. Teach knowledge about typical areas of science study such as weather, electricity, plant, animal life, and others	84.3	14.9	0.8
4. Help children learn concepts and ideas for interpreting their environment	84.2	15.5	0.4
5. Develop appreciations for and attitudes about the environment	82.4	17.1	0.5
6. Help children develop problem-solving skills	73.9	24.2	1.9
7. Develop responsibility for the proper use of science knowledge for the betterment of man	69.3	27.7	3.0
8. Prepare for high school science	42.8	45.2	12.1
9. Develop hobbies and leisure-time activities	40.9	50.4	8.7
10. Develop scientists	17.6	51.8	30.6

(Blackwood, 1965b, p. 180)

systems. The smaller the school, the less adequate was the availability of equipment and supplies for teaching science. Equipment that was available was not one item per classrrom, not to mention one item per child. Probably most served for demonstrations.

Blackwood identified 13 so-called barriers to science teaching and asked schools to rank these. The findings are shown in Table 7 on the next page.

When many of these barriers are considered, some could be eliminated through a well-designed inservice program in science and others could become less important. However, administrators, teachers,and consultants need to identify what will work best for their situation.

Hone (1970) speaks to some of these barriers, calling them "scarecrows." She lists three: inadequate teacher background in science, inadequate science equipment, and inadequate time and space for science. Hone considers these to be limitations in attitudes rather than in reality. She counters "inadequate science background" by saying that teachers do not have to tell children, they need to let children learn. She suggests that teachers can increase their science background by reading good elementary science textbooks and children's science books (1970, p. 322). In addition, teachers can read textbooks above and below the grade level they are teaching. Also, they should stress science based on investigation rather than on telling or reading.

Hone advises teachers to use everyday equipment and materials for science so that unfamiliar laboratory equipment does not distract the children. If such equipment must be used, its name and function should be provided several days prior to the science activity and the equipment allowed to remain in view until the novelty wears off.

TABLE 7

Barriers to Effective Science Teaching in Public Elementary Schools Ranked for All Schools, for School Enrollment Groups, and for Administrative Unit Enrollment Groups on Their Mean Degree of Difficulty: Unites States, 1961-62

Barriers to effective science teaching	Total schools	School enrollment groups: 800 and over	400 to 799	50 to 399	49 and under	Administrative unit enrollments: 25,000 and over	6,000 to 24,999	3,000 to 5,999	600 to 2,999	599 and under
Lack of consultant service	1	4	3	1	2	4	2	1	2	3
Lack of supplies	2	7	5	2	1	6	6	3	3	2
Inadequate room facilities	3	1	1	13	8	1	1	13	1	1
Insufficient funds	4	6	6	3	3	5	3	2	4	4
Do not have knowledge	5	2	2	4	7	2	13	4	5	8
Lack inservice opportunities	6	10	8	7	5	10	8	6	8	6
Inability to improvise	7	5	7	6	10	7	7	7	9	7
Do not know methods	8	3	4	5	9	3	4	5	6	10
Not enough time	9	8	10	8	4	8	9	8	7	5
Lack of community support	10	12	11	9	6	11	11	9	11	9
Teachers lack interest	11	9	9	10	13	9	10	10	10	11
What to teach not determined	12	13	12	11	12	13	5	11	12	12
Other areas more important	13	11	13	12	11	12	12	12	13	13

(Blackwood, 1965b, p.195)

Hone does admit that teachers sometimes have to struggle to find space for science materials but maintains that this can be done. In terms of time for science, several variations can be tried: a structured approach, based on the textbook, science integrated with other curriculum areas , and individual or group projects and reports based on children's special interests.

In 1963 another Office of Education study was conducted. This one looked at science teaching in the public junior high schools (Rogers, 1967). The questionnaire study was begun in Spring, 1963, with informal visits taking place through 1965. Rogers said that these visits indicated that practices had changed little, if any, since the data were collected.

Rogers found that all schools offered science courses at some grade level but not at all grade levels. General science was the most common course (95 percent of the schools), followed by life science-biology. In schools which offered general science, 80 percent offered graduation credit for it at some grade level (Rogers, 1967, p.27).

Teachers with science assignments made up 13 percent of the instructional staff in the junior high schools (grades 7, 8, and 9). However, relatively few had full-time science assignments. One-third of the teachers spent 10 hours or less in science teaching. The science teachers most commonly taught in a combination classroom-laboratory although one-fourth did not have any laboratory facilities. Forty percent of the largest schools used non-science rooms for science instruction. Most schools provided water, gas, and electricity for teacher demonstrations. Over 80 percent of the schools used NDEA funds to purchase science equipment. Virtually all schools used textbooks. Those books with the most recent publication dates were earth science books. General science textbooks were from two to four years old, but some were in use more than 14 years after the publication date.

Two-thirds of the schools had some type of inservice activity, with inservice activities occurring most frequently in larger schools. Teachers from two-thirds of the schools sampled had participated in an NSF institute. The smallest percentage of participants came from the largest schools.

Rogers suggested that, if science teaching in junior high schools is to improve, several things must happen. (1) Science teachers need to be assigned full time to their discipline. (2) Schools need to decide if they wish to continue broad, generalized science instruction in the form of general science courses or if curriculum revision needs to take place. (3) Class size and lack of equipment prevent the use of the laboratory in science classes. Changing both of these conditions requires expenditure of funds. (4) Related to the question of budgets, schools need to allocate more money for science equipment and supplies and increase flexibility in purchasing practices. (Less than one-fourth of the science teachers were permitted to directly purchase any supplies.) (5) Science reference materials, in the classroom and school library, need to be up-dated and up-graded. (6) More recently-published textbooks need to be purchased. (7) Materials for use with audiovisual equipment need to be made available to science teachers. (8) Ways of making science specialist or consultant help more available to small schools need to be identified and explored. (Less than 60 percent of the schools have such help available.) (Rogers, 1967, pp.29-30)

A series of studies about inservice teachers has been produced by the Research Division of the National Education Association (NEA) (1972; Graybeal 1974, 1976). The 1972 document is described as a quinquennial (every five years) census of the teaching profession, conducted to provide basic data on professional and personal characteristics of teachers, the current status of teaching conditions, home and family life, economic status, and teachers' civic and community activities. This publication provides

a status report for the years 1970-71 and indicates trends for the previous ten years (1961-1971). According to the information found in the Foreword, there has been a rapid expansion of the teaching profession during the 1960's. Because of this expansion the profession is younger, more dynamic, and more professional.

Although the NEA survey was of teaching in general, science is discussed from time to time in the report. Science is identified as one of the four most commonly taught subjects in secondary school. More men than women teach science (1972, p.46).

In discussing teaching assignments, the NEA Research Division reports that fewer people are teaching outside their major field of preparation in 1971 as compared to 1961. However, one in seven teachers is still seriously enough misassigned as to be teaching at least half-time outside the major certification field. Correction of misassignments has occurred primarily in medium and small systems (1972, p.29).

Nondegree teachers have almost entirely disappeared from the profession, Men, in 1971, continue to have academic qualifications superior to women, but women have improved their credentials greatly in the past decade. Higher degrees are still less common in small school systems than in medium and large ones.

Thirty-five percent of the teaching profession in 1971 was composed of people who had entered teaching within the previous five year period, with 1 teacher in 10 teaching for the first time in 1970-71. The collective experience of teachers has decreased from a median of 11 years to 8 years in the past decade (1972, pp. 11-23). In 1970-71, 9.5 percent of the science teachers were less than 30 years old (1972, p. 123).

When professional growth activities were considered, teachers had participated in workshops sponsored by their school system, taken courses in education, been involved in university extension courses, and/or worked

on the curriculum committee or in some other committee assignment. Those who had enrolled in college courses had taken more courses in education than in their subject fields and had taken more courses during the school year than in the summer. A higher percentage of elementary teachers than secondary teachers had participated in system workshops. A higher percentage of elementary teachers reported using educational television for professional growth (1972, p.46).

The 1974 and 1976 NEA reports focus on teacher supply and demand and will be discussed in the next section of this report.

The three volumes of the Ohio State survey which are in print (Schlessinger et al., 1973; White et al., 1974; Steiner et al., 1974) contain information of a national survey conducted to obtain data about practices, procedures, policies and conditions affecting science education in the public elementary and secondary schools during the 1970-71 school year. Volumes 1 (Schlessinger) and 2 (White) contain secondary school information. Volume 3 will provide descriptive data about elementary school science. Volume 4 (Steiner) provides results of correlation and multiple regression analyses of selected elementary school and teacher variables.

When data about teacher variables are considered, about one-half of the teachers responding had a master's degree or better and were generally adequately prepared for their assignment. General science teachers had depth in biology or physical science. Relatively few had depth in more than one area. Most had very little formal course work in mathematics. Earth science teachers had the least preparation in their major teaching area. Biology teachers were well prepared in biological science content but had relatively little preparation in chemistry or physics and also little preparation in mathematics. The majority of chemistry teachers had reasonable preparation in chemistry. Some chemistry teachers had background courses in

mathematics but a "sizeable number" (Schlessinger, 1973, p.148) had very little course work in mathematics. The preparation for physics teachers was similar to that for chemistry teachers. The investigators stated that physical science teacher preparation was difficult to summarize. If the teacher was teaching physical science in the junior high school, he or she usually had minimal preparation in physical science courses. Most physical science teachers had relatively little course work in mathematics unless they were also teaching physics or chemistry.

Over half of the teachers in the sample had attended NSF institutes: 9 percent had attended academic year institutes (AYI), over 50 percent had attended summer institutes (SI), and many had been involved in both AYI and SI activities or cooperative college-secondary school programs (CCSSP) or research programs. Those who had attended institutes were more likely to be using curriculum materials developed with NSF support. In addition they were also using laboratory activities and stressing pupil-centered activities (Schlessinger, 1973, p. 149).

The average length of teaching experience reported was 10-11 years but at least 25 percent of the science teachers in the study had been teaching for 4 years or less. Very few secondary school science teachers reported having any teaching experience at the elementary school level.

White and his colleagues, writing Volume 2, reported correlation and multiple regression analysis results of selected secondary school and teacher variables. They attempted to identify characteristics and conditions related to science course improvement projects (which they refer to as SCIP) usage, teacher self improvement activity participation, teaching practice preference and teacher satisfaction with science teaching careers.

They found that science course projects (SCIP) were in more use in large schools than in small schools. If enrollments in chemistry, physics,

and earth science were high in relation to school size, SCIP materials were more often (than not) in use but the reason for this finding was not clear. It could be that SCIP courses are popular with students or it could be that enrollments increased because of SCIP materials use. Use of SCIP materials was related to teacher participation in NSF institutes and to number of credits in science. Participants in NSF institutes tended to have more college science credits than did non participants.

In addition, NSF institute participants had more teaching experience, were older, were more likely to be male than female, and generally worked in larger schools. When teachers had been selected to participate in one NSF program, they tended to apply for and be selected for other NSF programs. The investigators reported an "indication" that SCIP teachers were less in favor of lecture-discussion and demonstrations as learning activities and more in favor of laboratory activities. They also favored using grading methods other than test scores. Apparently they valued teaching activities and grading methods consistent with the intentions designed into the SCIP materials.

In analyzing the use of SCIP materials in the elementary schools, Steiner et al. (1974) reported that the overall use was 27 percent. Science Curriculum Improvement Study (SCIS) Elementary School Science (ESS) and Science-A Process Approach (SAPA) materials all were in use, with SAPA being used as much as SCIS and ESS together. An exception to this finding was that, in the Rocky Mountain region, ESS and SCIS were used two to three times more frequently than SAPA. Overall, SAPA was used by about 14 percent of the sample schools.

A significant predictor of the use of SCIP materials in elementary schools was the teacher's use of group and individual laboratory activities. Another significant predictor was consultant or supervisory help provided by

the school. Attendance at SCIP workshops and the use of SCIP materials were closely related. However, when techniques for teaching science were identified and ranked, the most common was that of lecture-discussion followed by science demonstrations and then laboratory activities, although there was variation within each geographic region (Steiner et al., p. 72). The best predictor of more frequent use of laboratory activities for teaching science was whether the teacher currently or previously had taught a science course improvement project.

The authors of Volumes 1 and 2 (Schlessinger et al, 1973; White et al., 1974) reported that secondary school science teachers reported they were very satisfied with science teaching as a career. Reasons for high satisfaction were not clear although White et al. (1974) speculated that the dissatisfied had probably left teaching and were not around to respond to the survey. This could possibly be inferred from the fact that those expressing the most satisfaction with teaching science had been at it the longest. Steiner et al. (1974) reported that elementary school teachers responses ranged between neutral and satisfied with science teaching, although somewhat closer to satisfaction. Those teachers not solely responsible for teaching science (having consultant or supervisory help) were more satisfied than those who worked alone. The best predictor of satisfaction was whether the teachers felt that a lack of ability to improvise materials and equipment presented them with difficulty (Steiner et al.,1974, p.73). This continues the trend of Blackwood's barriers, or Hone's scarecrows, depending upon your point of view.

A study conducted by Mason and Craven (no date) focused on the effects of new elementary science curriculum projects on methods courses. They received 518 usable returns to the 2000 questionnaires they mailed out.

Eighty percent of their respondents said that the new projects had a definite impact on the methods course in their school, with SCIP materials being used in the laboratory or small group situations. However, 31 people reported that students had little, if any, exposure to the new materials and 93 said students did not have direct experience with SCIP materials (Mason and Craven, pp. 16-18).

Lawrenz (1974) collected questionnaire data from 344 science teachers in 12 states (three geographic regions) about their perceptions of their own skills and of school conditions. She found that 62 percent of the junior high school science teachers and 72 percent of the senior high school science teachers held a bachelor's degree in science, with biology being the most common major. Thirty-eight percent had a master's degree. All of the respondents had positive attitudes toward science.

When teachers were asked to rate their own skills, the lowest rated item for both junior and senior high school science teachers was their knowledge of curriculum techniques. Senior high teachers were relatively happy with their teaching load and considered their students well behaved. Junior high science teachers were less satisfied with their load and considered their students less well behaved (both significant differences). Junior high school teachers also felt fewer science courses were available and that the courses were less appropriate for student needs (Lawrenz, 1974, p.494). In addition, the junior high school science teachers reported that space for science was not adequate, laboratory space was insufficient, and they were significantly less satisfied with storage space (Lawrenz, 1974, p.495).

Lawrenz concluded that inservice activities probably should be in the form of short summer institutes. These programs should stress areas of curriculum techniques and the use of evaluation to diagnose difficulties.

Emphasis should be placed on individualized instruction and how to use it. Teachers should be provided with information about available science career opportunities for their students. Teachers' reactions to Lawrenz's questionnaire indicated they would not be too interested in inservice courses designed solely to improve their knowledge of subject matter (Lawrenz, 1974, p.495).

Stronck (1974) used a questionnaire survey to gain information from 309 people in the state of Washington about their perceived needs for inservice programs. All respondents (elementary teachers, secondary teachers, administrators) were interested in how to coordinate a K-12 sequence of science concepts and processes. They wanted inservice programs to describe recent advances of scientific knowledge and to indicate the relevancy of scientific topics for students. Elementary teachers were more concerned, than were secondary teachers, about the effective management of curriculum materials, the individualization of instruction, and emphasis on processes of science.

Stronck suggested that inservice programs should concentrate on (1) the coordination of a science sequence, K-12, (2) recent advances in scientific knowledge, (3) the relevancy of scientific concepts to the lives of students, (4) the efficient management of curriculum materials, (5) individualization of instruction, and (6) ways to evaluate the quality of instruction (1974, p.508).

Inservice Education in Science: An Overview. The need for inservice education in science continues, despite the large number of teachers who have participated in NSF-funded programs and activities as well as those inservice programs operated by local school systems or other agencies. This may seem contradictory but it is not meant to be so. Perhaps a discussion of factors and forces involved may help clarify the situation.

Certification practices do not mandate post-graduate college credit in science (or even college credit, in all states) for second-level certification. The most common form of inservice activity may be that of released time to attend conferences and conventions (Hite and Howey, 1977). Inservice programs and practices vary, sometimes with school size, sometimes with funding. However, explaining lack of inservice activity because of lack of funds or a tight economy may be a scarecrow, to borrow Hone's terminology.

Programs and practices probably also vary because "unlike the preparation of beginning teachers, inservice education has no tradition of what constitutes a basic program" (Hite and Howey, 1977, p. 5). This variation is not entirely a bad thing. Inservice activities ought to be designed to meet the needs of the local situation. Inservice education has traditionally been the responsibility of the local school district through its administrators. Inservice education depends, to a large extent, on who controls the rewards system. If administrators stress graduate credit, they have given control of inservice activities to the colleges and universities. College credits may, or may not, improve what goes on in classrooms.

Science teachers appear to be younger and better educated today than in past years. However, they frequently lack breadth in the sciences as well as lacking depth in certain science areas. For secondary teachers, participation in NSF institute programs has provided a better content background in science as well as increasing their tendencies to use pupil-centered methods of teaching science.

Again, despite the fact that many teachers were involved in NSF programs, science knowledge is constantly changing and the amount of knowledge is increasing rapidly. Even though many of the science course content improvement projects have been in existence for more than ten years, teachers still indicate a need to become more familiar with these materials. An

example of this is to be found in data reported for the Comprehensive Program for Science Teacher Education at the University of South Dakota. In an evaluation report issued in 1972, 75 percent of the program participants wanted more work with science course improvement project materials (Sagness and Bertrand, 1972, p. 33). In the second evaluation report of this program, the authors reported that 78 percent of the Unitary participants and 56 percent of the AY participants desired more work with science course improvement project materials (Sagness, Petersen and Ketterling, 1974, p. 33).

The teachers who reacted to the evaluation questionnaires discussed in the preceding paragraph were secondary school science teachers who work with pupils in grades 7 through 12. There also is a need for inservice education activities in science designed for elementary school teachers. There were fewer NSF institutes and programs designed to help elementary teachers improve their content background in science than those for secondary teachers. In addition, certification standards for elementary teachers, in terms of the amount of science content required for certification, do not appear to have changed markedly over the last 20 years. Steiner's report (1974) of a national survey of selected elementary school and teacher variables contained the finding that the most common technique for teaching science in the elementary school was that of lecture-discussion. This would appear to indicate that more inservice programs are needed to help elementary teachers effectively use (i.e., in the manner for which they were designed) elementary school science course improvement projects.

If we recall the finding that the less recent a teacher's undergraduate preparation has been, the less likely he or she is to return to school, we need to consider the implications of this for keeping teachers current in both science knowledge and teaching techniques. Mertens and Bramble (1976b)

report a survey done by Arthur D. Little, Inc. which documents the main problems of one group of teachers: those in the Appalachian Region. This survey, conducted in 1970, involved a 20 percent random sample of 162,000 teachers. Eighty percent of the teachers surveyed felt their training was sufficient in the application of educational theory, teaching methods, and training in the subjects they taught. However, the majority felt their training was not sufficient in methods for teaching disadvantaged students, knowledge of vocational opportunities open to their pupils, reading instruction, curriculum planning and development. Both scientific equipment and laboratories were perceived as being inadequate. Many had recently taken a college course for credit. But, 11 percent last took a college course six to ten years ago and 13 percent last took a college course for credit more than ten years ago (Mertens and Bramble, 1976b, pp. 15-16).

Although the 1970 survey indicated that Appalachian Region teachers felt they had sufficient training in the subject they taught, the need for inservice activities in science was identified, six years later, when some needs assessment activitities took place. A series of needs assessment conferences, held at 12 sites in Appalachia in the spring of 1976, resulted in identified needs for inservice training for elementary and secondary teachers in specific content areas as well as for skills and strategies (Mertens and Bramble, 1976a, p. 14). Ratings of 1-2 indicated a very strong need and of 3-4, a strong to moderate need. The mean rating for inservice education in science for elementary teachers was 2.87. For secondary teachers, the mean rating for science inservice education was 2.96 (Mertens and Bramble, 1976a, pp. 17, 19).

Needs for inservice education not only vary with the geographic area being considered, they also vary with the educational level being studied. Earlier in this subsection, there was some discussion of the fact that

elementary teachers have had fewer opportunities to participate in NSF institutes than have secondary teachers. Although secondary school science teachers have benefitted from NSF programs, there is a subset of secondary school science teachers whose teaching assignment indicates a possible need for effective inservice programs. This subset consists of the people who work with junior high school students in general science classes or in whatever sequence of science courses is available for grades 7 through 9.

Junior high school science teachers are not likely to be specifically educated, and certified, to work with the students of this particular age group. Most states do not have a separate certification for teaching in junior high or middle schools. If state certification procedures do not require special preparation programs for junior high or middle school teaching, there is little incentive for colleges and universities to design such programs.

Schlessinger et al. (1973) reported that general science courses in junior high schools were decreasing but science courses are still being offered for grades seven, eight and/or nine. If the old general science course is not offered, the common patterns are life science in grade seven, physical science in grade eight, and earth science in grade nine or physical science, earth science, and life science in grades seven, eight and nine respectively. Relative to teacher preparation, the OSU study (Schlessinger et al., 1973) reported that relatively few general science teachers had depth in more than one science area.

In addition, the respondents in Lawrenz's study (1976) indicated they were less than satisfied with their teaching load, considered their students less well behaved (than did senior high science teachers), and felt courses were less available and less appropriate for student needs. They also felt

their classroom conditions were in need of improvement in terms of space for science, particularly laboratory activities, and for storage of equipment.

While it is true that inservice programs cannot provide remedies for all of these deficiencies, such programs can be designed to provide junior high science teachers with more knowledge about the age group with which they are working and about a variety of instructional methods or teaching techniques, and with some suggestions concerning ways to improvise until their less-than-adequate teaching conditions are improved.

Up to this point, the discussion of the need for continued inservice activities has focused on those designed primarily to up-grade or up-date teachers' content knowledge. The article by Lawrenz (1974) reported earlier in this section provided some data relative to additional areas which should be emphasized in inservice programs. The report by Mertens and Bramble (1976a) also provides information relative to inservice needs related to teaching skills and strategies.

When skills and strategies needs were identified by participants in the Appalachian area needs assessment conferences were ranked, there were several needs that, while not content-specific, apply to science education. Participants ranked strategies for motivating students as their greatest need. Methods for individualizing instruction ranked second. Ranked fourth was the need for ways of teaching both fast and slow learners. Promoting independent and self-direction in students was ranked fifth as a needed skill. The use of problem solving and decision making strategies was ranked sixth. Inquiry discovery techniques for instruction was ranked eleventh as a needed strategy for teachers (Mertens and Bramble, 1976a, p. 20).

The University of South Dakota teacher participants indicated they would like further opportunity to work on teaching skills such as questioning or those skills developed through microteaching (Sagness and Bertrand, 1972,

p. 34; Sagness, Petersen and Ketterling, 1974, p. 34). Welch (1977a) reported that a sample of principals and science teachers in 376 secondary schools (grades 7-12) located in 12 mountain, plains, and southern states identified needs for secondary education in three areas: information processing and decision making skills, basic skills, and student self-esteem. Participants also considered these areas as important for science education as well as for secondary education in general (Welch, 1977a, p. 10).

Mertens and Bramble reported that when priority needs identification was considered, in the 1976 Appalachian needs assessment conferences,

> . . . Inservice training for teachers and administrators in such areas as human relations skills, curriculum design, affective education, interdisciplinary education, value clarification, management, and competency-based instruction was mentioned as a priority in eight of the nine states where priorities were identified in the education area. This agrees with the very strong ratings found for the skills and strategies need category overall. (1976a, p. 30)

Information from these documents would seem to imply that while inservice education activities should be continued, the focus must be broadened to include more than the acquisition of recent science content. The teaching skills and methodologies necessary to promote student learning of science content must also be included in the inservice programs.

Why should inservice education continue? The rationale for this appears to be based on the premise that if teachers are better prepared in their content area and more skilled in teaching techniques and strategies, they should be able to better promote student learning. Is there any validity to this assumption? Willson and Garibaldi (1976) think they have identified supportive evidence.

Willson and Garibaldi investigated the question of whether there is any evidence that precollege student cognitive achievement has been increased because of teacher participation in NSF-sponsored institutes. They cite Helgeson's

review of NSF programs and indicate that he identified 16 separate articles inferring student gains. However, not all of these were experimental in nature so Willson and Garibaldi conducted their own investigation. They examined data from teachers and students involved in comprehensive teacher education projects funded by the National Science Foundation (science programs in Wyoming, South Dakota, and Mississippi and mathematics programs in California and Indiana). They found a consistent trend in the direction of better student performance with increased teacher NSF participation.

When the results of two planned orthogonal constrasts were analyzed, the investigators reported that the data suggest that "teacher attendance at institutes is associated with higher student achievement than no attendance, and that the students of teachers with high institute attendance perform better than students of teachers who have attended only one or two institutes" (1976 p. 437).

Willson and Garibaldi concluded that "a real institute effect is present" (1976, p. 437). They consider the fact that the lack of significance at the junior high school level may be due to the selectivity of senior high school science classes which are elective as opposed to the compulsory junior high school science classes for all students.

So strongly convinced are Willson and Garibaldi of the impact of institute attendance on student cognitive achievement, that they make the following prescriptive remarks:

> ...For the secondary science and mathematics teachers, it is recommended that they continue to attend workshops, institutes, and courses in the science area during their active professional lives. The apparent stimulus of such attendance is to improve their students' achievement. Although compulsory attendance is rarely desirable from a motivational standpoint, it is unlikely to result in negative effects and may result in improved student achievement for all teachers. For the school, school district, or other administrative agency concerned with teachers' professional

development, it is recommended that continued, periodic attendance be required of all science and mathematics teachers as conditions of retention and advancement. With such requirement should be a comparable oppourunity and incentive, such as leave time, tuition and expense money, and pay. Although school districts may be able to produced effective science education for teachers in some cases, it falls to state educational agencies, universities, and national agencies and professional organizations, such as the NSF, AAAS, or NSTA, to provide the bulk of workshops, institutes, and coursework for science teachers. Those responsible for funding institutes and workshops should be made aware of the research supporting maintenance of programs such as the NSF precollege science and mathematics training programs. (1976, p. 438).

TEACHER EDUCATION AND SCIENCE TEACHING TODAY

This section of the report might be entitled "What's It Like Out There?" with a subtitle of "Implications for Science Teacher Education." Considered in this section are factors such as teacher supply and demand, teachers' rights and responsibilities as negotiated by professional organizations and/or established by legal precedent, and pressures that influence science teaching such as decline in achievement as evidenced by National Assessment of Educational Progress (NAEP) scores and community concern over textbooks and their content. Related to all of these aspects of science teaching is the continuing concern, and need for, inservice education.

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1. Curriculum reforms in science education have taken place. How well these reforms have met their goals in terms of implementation in the schools is still a subject of debate.

2. Some authors consider that there has been a second generation, or second round, of curriculum reform, resulting from the perceived lack of success of the first generation of reforms.

3. The teaching profession expanded during the 1960's. Today, much discussion centers on the fact that many people prepared to teach are unable to secure a teaching position. Does a teacher surplus exist in fact? The answer frequently depends upon the source responding, as well as the content area under discussion.

4. As professional organizations gain strength, more and more school matters have become the subject of negotiation.

5. Increased protection of teacher rights appears to be the current trend.

6. Despite teacher militancy or increased organization, teachers and curriculum committees (and schools) are still subject to parental and community group pressures.

7. Schools are subject to demands for equal time for topics such as creationism. Some groups express a disillusionment with science.

8. Science teacher educators need, for a variety of reasons, to get more involved in inservice teacher education.

Secondary School Science Education and Curriculum Reform

Many factors provided the impetus for science curriculum reform. During World War II, general lack of knowledge in science and mathematics was identified. Funds for science were appropriated by the U. S. government. Money became available for science curriculum reform projects. Dede and Hardin characterize these reform projects as differing from other reform movements in that (1) there was an attempt to replace the current science curriculum rather than revise it, (2) professional scientists, rather than educators, provided the leadership, and (3) funds came from foundations and federal grants rather than from state and local sources (Dede and Hardin, 1973, pp. 485-486).

What was not changed is also important. The sciences traditionally taught remained as important to teach. Staffing and administrative constraints were not drastically modified. Although the emphasis was on science for gifted students, curricula were also developed for other groups of students. In addition, it was assumed that the new curricula would be used and used correctly (Dede and Hardin, 1973, p.487).

When the reforms met with mixed results, the criticism which resulted combined with various forces acting on the American society in the 1960's. And, a second round of curriculum reform activity took place. Guidelines for teacher education programs also were re-written (see section on guidelines for preservice education, earlier in this paper). Dede and Hardin feel they can identify five characteristics common to the second generation of curriculum reforms: (1) new emphasis on the interrelation of scientific disciplines, (2) new consideration of the social and cultural consequences of science, (3) new role for the teacher as interpreter and mediator of learning, (4) new cooperation of teachers and professional educators with university scientists in all stages of reforms, (5) new flexibility of

high-interest student materials, and (6) behavioral objectives and performance criteria spelled out (1973, p. 489).

While Dede and Hardin consider the second generation reforms as a consolidation of traditional and first generation reform strengths, they also point out what they consider significant weaknesses. Aside from needing evaluation concerning usage and effectiveness, the second generation reforms are only bits and pieces of the science education program. In addition, they have been designed to fit existing school organizational structures, which are now changing. Second generation materials still depend on testing, grading, and teacher observations although these items have not been shown to be reliable indicators of professional achievement in science. Nor do these materials prepare students for roles they may assume in the future (Dede and Hardin, 1973, p.490). They speculate that a third round of curriculum reform movement may take place, due to unsatisfied needs.

Inservice teachers who read articles such as that just discussed are faced with a problem: to get geared up for second-generation reform projects (which the authors imply are presently available) or to wait for the appearance of third-generation curricula? Is Dede and Hardin's description of the curriculum and instructional materials situation in science education an accurate one? Do science educators commonly accept their description of changes that have taken place in curriculum reform? From what data base did they draw their findings? A science teacher who wants to keep up to date needs to look around for inservice activities and workshops designed to help him learn to use, or to modify, currently existing curricula and related instructional materials.

Another article related to the second generation of science curricula (Zoller and Watson, 1974) contains references to "proposed" second generation materials, indicating the authors are not so certain (as Dede and Hardin seem to be) that such curricula already exist--although they appear willing to grant that reforms are taking place. Because many of the so-called first generation curriculum reform materials contain references to making them

"teacher proof," Zoller and Watson emphasize the formulation of teacher education programs that can produce "curriculum proof" teachers. They stress that there is a need to produce teachers capable of functioning in an innovative mode and with nontraditional constraints (Zoller and Watson, 1974, p.94). They emphasize that any curriculum change is brought about only to the extent that teachers understand its philosophy, agree with its objectives, become familiar with its strategies, know how to implement it, and are willing to do so (1974, p. 94).

Zoller and Watson emphasize their concern that future innovative science curricula be properly implemented for nonscience students (who, they consider, constitute the majority of high school students). They stress that teachers should be less concerned with what is "typically academically respectful" and more concerned with what is "educationally relevant and essential for the individual local students . . ." so these students understand (1) themselves in a changing society, (2) the issues which determine their lives, and (3) the physical world they have to adapt to and cope with (1974, p.101).

Teacher training programs, according to Zoller and Watson, should present the teacher with as many alternatives as possible while simultaneously encouraging him to create additional alternatives (1974, p. 101). Selection, self and other, is necessary so that those teachers who graduate from such programs are wise, thoughtful, humane, mature, compassionate, socially-oriented, and educated (1974, p.101). Such selectivity, while highly desirable, implies that teacher supply and demand is such that teacher educators and administrators can afford to be discriminating.

Teacher Supply and Demand, Focusing on Science

Although the NEA's Research Division reported, in 1972, that the teaching profession had expanded during the 1960's another NEA report which was published in 1973 contained the information that at least 10.2 percent of the

1972 education graduates actively seeking jobs in teaching were unable to find positions. This statement refers to teacher education graduates as a group rather than applying to all subject areas.

In an article published in 1972, Bartels reported that, in 1970 teacher demand still existed for teachers of mathematics and of natural and physical sciences. Table 16, in the NEA document (1973, p.22), identified the areas of natural and physical sciences (as well as mathematics, industrial arts, and trade, industrial, vocational and technical teachers) as having a "low supply" of teachers.

Stinnett (1967) reported that a number of factors contributed to the teacher shortage of the 60's: growing school enrollments, demand of industry for college graduates, appeal of graduate education, and demand for teachers for new federally sponsored programs. Stinnett also indicated that some persons were discouraged from teaching by the less than adequate salaries, the many trivial administrative details teachers had to perform, and by the lack of status commensurate with the education involved in preparing for a teaching career.

These factors caused state certification divisions to issue emergency certification, caused school districts to set up double shifts of schools and to increase class sizes. In addition, teacher education institutions accelerated programs for preparing teachers. Some lowered admission criteria and allowed people who really should not have been certificated to become teachers. At present there is a decline in the birthrate, a tighter economy and a decrease in the number of new teaching positions. However, some teacher education institutions are continuing to prepare large numbers of teachers (Arnold et al., 1977, p. 47).

Are these institutions doing their graduates a disservice? Are they maintaining college faculty and programs under false pretenses? There are mixed

opinions concerning the teacher supply situation. Articles in the popular press indicate on oversupply. Others have opposing views.

Regier (1972, p. 37) contends that there really is not an oversupply of teachers, there is simply an undersupply of money. He reports that the United States spends only seven percent of the gross national product on education. If spending priorities were re-ordered, schools could add more curriculum offerings, could reduce class size, provide additional instructional services, and replace those teachers who had substandard qualifications (1972, p.10).

The National Education Association (NEA) also contends that there is not an oversupply of teachers. In a research memo published in 1976 (Graybeal, 1976), the NEA reports that 1975 was the third consecutive year that the number of teacher education graduates decreased (by 8.3 percent). The year of the all time high was 1972, when 317,254 students graduated, prepared for teaching.

In analyzing the decrease in teacher education graduates, the NEA contends that 696,200 beginning teachers were needed in the fall of 1975 to raise the quality of public school programs and staffing to minimum levels. The number of beginning teachers needed was 503,500 more than were available from the college classes of 1975. What does raising the quality of public schools and staffing to mimimum levels imply? According to the NEA, this would be accomplished through (1) improved staffing, (2) taking care of teacher turnover, (3) replacing people with substandard qualifications, (4) reducing class size, (5) taking care of the increase in special education, (6) reducing misassignment of teachers, and (7) reinstating cut programs (1976, pp. 5-7).

This, however, is an ideal situation. In reality, the number of prospective teachers seeking positions exceeds the number of teaching positions actually open. In 1974,47.9 percent of the teacher education graduates reported securing

employment as a teacher as compared to 74.4 percent of the 1962 graduates (1976, p. 1).

Science teaching opportunities? The 1976 research memo provides the information that teaching assignments in which the supply is least adequate are those of mathematics, natural and physical sciences, distributive education, industrial arts, and agriculture (1976, p.1).

Are science educators and prospective science teachers aware of these statistics? Hausman and Livermore (1976) are afraid they are not. These authors contend that people are not going into teaching because they think the science teaching positions are not available. In addition, teachers who leave teaching may not be replaced, for budgetary reasons. People who might consider interrupting their teaching careers or leaving teaching are electing to remain in their jobs. Teacher education programs are decreasing the number of their graduates (in some cases because students are not enrolling in the programs). They see this situation beginning in the early 1970's. By the 1980's people will be retiring from teaching, but there will be few replacements. Those persons educated earlier will have out of date content backgrounds. The result? Teacher education institutions will have to gear up rapidly to meet the crisis.

This scenario was based on information from RAND Corporation studies for secondary school teachers in general. RAND data indicate that the decline in production of BA graduates began in 1966. In 1968, 23.5 percent of the freshmen chose to major in education. By 1974, according to information from the American Council on Education's annual surveys, only 7.7 percent of the college freshmen chose an education major. The teacher "surplus" will end by 1980, based on supply conditions alone. Hausman and Livermore report that NEA information showed an increase in BA output in science from

1960-1970 of 69 percent and then a drop from 1972-1973 by 2.3 percent (1973, p.3)

They remind science educators that the bachelor's degree candidate of 1982 is the college freshman of 1973. Hausman and Livermore encourage those who prepare science teachers to get ready to recruit these students and then to prepare them for the future rather than for science education as it existed in the 1950's and 1960's (1976, p.6).

Professionalism and Responsibility

Stinnett remarked, in his 1967 paper, that lack of status discouraged many people from a career as a teacher. One way that teachers have attempted to improve the attractiveness of teaching as a career is through increased professional activity. While this may be construed to mean such activity as that which produced the NSTA position statement of science curriculum entitled "School Science Education for the 70's" (Berkheimer,1971) or the NSTA publication on science facilities (Novak, 1972), it more commonly means that local teachers associations have become more assertive in salary negotiations and in demanding participation in curriculum decisions.

These types of science education activities are seldom the focus of research studies or journal articles but they are a fact of life. In addition, the National Education Association and the American Federation of Teachers (AFT) have backed their members when teachers' actions have resulted in court cases. In a document entitled "Protecting Teacher Rights, A Summary of Constitutional Developments" and prepared for the National Education Association by its general counsel, the final sentence aptly describes the situation. After a note of caution about legal decisions not being a static area, the author writes ". . .We may conclude with the observation that the mode is change and the direction is toward increased protection of teacher rights." (Chanin, 1970, p.41)

How does the fact of professional negotiations influence the science curriculum? Perhaps through having to pay teachers overtime if special meetings are called. Perhaps in having to clear any curriculum innovations through a curriculum bargaining committee and its chairman before these can be tested in classrooms (Kiernan, 1975, pp.15-16). Nevertheless, having an active local education association does not thoroughly shield science teachers from pressures.

Pressures, Politics and Science Teaching

Although the focus of this subsection is treated in more detail in other sections of the final report, namely those concerned with accountability and with needs assessment, it seems appropriate to consider these factors within the context of teacher education, preservice and inservice. Some science teacher educators appear to be saying, when one reads journal articles or reports of papers presented at national meetings, that science education can best answer the demand for accountability by putting teacher education programs, and high school graduation requirements, in the format of competencies to be met. At the same time, some of their colleagues are countering these arguments by maintaining that the science curriculum improvement projects, with their emphasis on the structure of the discipline, have served to alienate young people from science and that we need to make education and schools more humanistic. They consider the humanistic approach to be at the opposite end of the continuum from CBTE and behavioral objectives. Whose views are more correct? Or, does the almost-ideal situation involve a mix of both types of approaches? These debates are yet, if ever, to be resolved.

Even if science educators ignore philosophical questions, they find it difficult to ignore the public's reaction to the findings of the National Assessment of Educational Progress (NAEP), and of findings of a decline in

learning indicated by the downward trend in scores on College Board Examinations (Kiernan, 1975, p.5). Since 1963 there has been a drop on the verbal portion of 44 points and on the math portion of 30 points of the Scholastic Aptitute test (SAT). In September, 1975, it was reported that scores had declined 10 more points on verbal ability and 8 points on mathematics skills.

The American College Testing Program, which involves approximately one million college-bound students each year, reports the ACT composite scores (averages of scores in English usage, mathematics usage, social studies reading, natural science reading) have declined by approximately one score unit over the past 10 years. This is roughly comparable to a decline of about 20 points on College Board tests. One bright spot: natural science scores have remained relatively stable although mathematics scores are down by one and one-half units (Kiernan, 1975, p.8).

National Assessment data do not concentrate heavily on the college-bound. Ten learning areas, of which science is one (and mathematics is another), are being studied. Persons drawn from populations aged 9, 13, 17, and 26-35 (young adults) are being tested.

Science knowledge was tested in 1969-70 and again in 1972-73. When data from these two rounds of testing were compared, there appeared to be cause for concern among science educators at all levels. The scores showed that (1) approximately 65,000 fewer 9-year-olds nationally could answer typical science questions in 1973 than in 1970, (2) approximately 70,000 fewer 13-year-olds could respond satisfactorily to typical science questions in 1973 than in 1969, (3) approximately 80,000 fewer 17-year-olds could answer science questions correctly in 1973 than in 1969 (Kiernan, 1975, p.11).

Four major objectives relative to science were used, along with sub-

objectives, in the formulation of test questions. The major objectives were (1) students should know fundamental facts and principles of science, (2) students should possess the abilities and skills needed to engage in the processes of science, (3) students should understand the investigative nature of science, and (4) students should have attitudes about and appreciations of scientists, science, and the consequences of science that stem from adequate understandings (Ahmann, 1976, p.23).

How do science teachers respond to parents of their students when these people who vote for, or against, school levys and bond issues question the science curriculum? A group of people convened for a special national seminar co-sponsored by the Thomas Alva Edison Foundation and the Institute for Development of Educational Activities, Inc. (I/D/E/A) identified 20 possible causes of the drop in learning. Among these "causes" were television, work/study programs, innovations in education, permissive attitudes toward youth that result in discipline problems for teachers, broken homes, drugs and alcohol, and short-term courses, to name some factors the group identified. They felt that the responsibility for the decline should not be assumed by teachers alone but that it must be shared with parents, courts, legislators, bureaucrats, and school administrators (Kiernan, 1975, p.19).

Another possible explanation that is less gloomy has been presented by Welch (1977b). Welch identifies several possible explanations for declining test scores: (1) invalid tests, (2) failure of schools to do their job properly, (3) out of school influences, (4) less time spent on science, and (5) reduction in intelligence related to genetic factors and increasing family size. However, he goes on to speculate that perhaps the drop in test scores is due to an increase in the affective outcomes of schooling.

Welch supports his hypothesis with data from 350 science classes.

Pupils in 1972 and in 1976 were tested by using the Welch Science Process Inventory and the Test of Achievement in Science, a test of NAEP items. In addition, the 8,000 pupils also completed two affective measures: Science Attitude Inventory and Learning Environmental Inventory-Satisfaction. Welch found statistically significant declines on the achievement test and the process inventory. However, he also found significant gains on measures of class satisfaction and science attitude. Welch speculates that, while students may be learning less science, they are enjoying it more.

Is student satisfaction with, and enjoyment of, science valued sufficiently to convince parents and other tax-payers that present curriculum materials need not be replaced? There is another concern, perhaps more prevalent among elementary teachers than among secondary school science teachers: if school systems do revise programs to reflect community concern for a "return to the basics," will science be considered "a basic"? ("Back to Basics...," Science Education News, April, 1972).

Secondary school science teachers find themselves more concerned by pressures exerted by groups objecting to curriculum selection or textbook adoption. This situation is described in Science Textbook Controversies and The Politics of Equal Time by Nelkin (1977). In addition to providing historical information about the development of the evolution-creation controversy as this affects education, Nelkin traces the development, and splintering, of various creationist groups.

Nelkin contends that the individuals and groups objecting to some of the textbooks and curriculum projects in use in today's schools do not represent, for the most part, the deprived and marginal subcultures. Instead, these people's requests to share in textbook selection and their demands for equal time in the curriculum for their views originate from a sense of decreased power and a loss of local control to technical bureaucratic institutions. Such institutions, they feel, do not represent their interests.

Nelkin devotes considerable space in her book to a discussion of the events that took place in California when creationists were able, for a time, to modify "The Science Framework for California Schools," a set of curriculum guidelines for public school science programs (Chapter 6, pages 81-103). In addition, what Nelkin terms "the MACOS dispute" is described in Chapter 7.

In Chapter 9, "Science and Personal Beliefs," Nelkin suggests that textbook controversies should cause people to wonder about the public understanding of science (1977, p.145). She reports that, in 1959, a public opinion survey reported that 83 percent of the American population thought we were better off because of scientific contributions to health and to a higher standard of living, However, 47 percent thought that science made our way of life change too fast, while 40 percent feared the growth of science would bring about increased centralized control. In 1972, a Harris poll found that 76 percent of the respondents worried about excessive concentration on science and 72 percent believed science was making people too dependent. But, 89 percent saw scientific progress as necessary for a high standard of living (Nelkin, 1977, p.146). Nelkin suggests that "Ambivalent attitudes are often matched by confused comprehension." (1977,p.147)

Implications for Science Education

If, as Hausman and Livermore and others predict, many teaching staffs will come to consist of older tenured teachers and if, as the Mills document (1963) reported, the older teachers tend not to return to school, these facts are important for science educators to consider. Until the late 1970's inservice education had not been a major concern of most teacher education institutions. Hite and Howey suggest several reasons why inservice education should have a higher priority among teacher educators: teachers are remaining on the job longer and are less mobile, and state

departments of education are certifying fewer teachers so certification standards have less impact on the quality of inservice teachers (1977, p.4). In addition, some people are suspicious of teacher education and of the idea that teachers and schools can contribute significantly to goals in the areas of interpersonal growth and social reconstruction (Hite and Howey, 1977, p.24).

Programs and activities must be designed for inservice science teachers, at all grade levels. Our incentive remains the same as that identified at a 1953 conference convened by James B. Conant to study the nation-wide problems of science teaching in the secondary schools:

> We need science teachers who have an awareness of scientific problems, who grasp every opportunity to encourage an inquisitive pupil toward further study and investigation, who know how to direct laboratory work and student projects, and who have a desire to make science classes a stimulating part of every high school curriculum. (Watson et al., 1953, p. 41). . . When we consider how inevitably science affects our national economy and national defense, mediocrity in science teaching is not only insupportable, but perilous (Watson et al., 1953, p. 48).

IV. CONTROLLING AND FINANCING EDUCATION

Controlling Education

The role of the state in shaping school policy has been central to American education because the U.S. Constitution reserves authority over education and because Dillon's Rule still lives. (Dillon's Rule refers to a nineteenth century judicial opinion that characterizes the basic tie between state and local governments. In essence, the state can create and destroy all local units and it can grant or withhold authority for them to act.) (Wirt, 1977, p. 164).

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1. Between 1955 and 1976 the state governments have <u>expanded</u> their activities in the number of functions in which they are involved in school structural organization, finance, curriculum, and instruction.

2. The influence of the state governments on science education has <u>increased</u> since 1955. These influences on science education are due to regulations that (a) are related to science and (b) are not related to science. Both types of regulations can provide positive or negative influences on science education.

3. State governments differ markedly in the types and extent of influence they exert on elementary and secondary education. Regional patterns do exist.

Regardless of whether one examines educational function, structure, finance, or instruction, it is clear that the states have expanded their influence over the last century (Fuller and Pearson, 1969b). During the last 20 years this pattern has accelerated.

Examples of expanding control can be given in several areas.

1. Policies regarding school size and school consolidation. Reduction of school districts was extensive in the 1950's, 1960's and early 1970's. While the action has varied from state to state, in a recent year (1973-74) the number of school districts in four states was reduced by 20-25% in one year. Four other states reduced the number of school districts during the same year by 10-20%.

This activity has had many influences on schools including increasing the size of many schools, increasing the number of students transported to school by public means, increasing the number of science offerings in a typical school, and decreasing the time students spend at school before and after classes.

2. Policies regarding the school curriculum. States vary extensively in the amount of control that is exerted over the curriculum. The method of control also varies in legislative and regulatory forms.

Many of these affect science through specified requirements that relate to science. These include such items as (1) specified graduation requirements for science, (2) specified requirements for teaching conservation, environmental education, elementary school science, or secondary school science, hygiene and health, alcohol and drug education, sex education, nature study, outdoor education and similar courses or topics, and (3) stated objectives of the state school system that include science.

Some state requirements influence science in a negative way if they make (1) time demands that require institutional program requirements to reduce science or require students to reduce science study and (2) money demands that require funds be reduced for other programs. These requirements fall into the same categories as those in the previous paragraph: (1) specified graduation requirements that demand more credits than those demanded for science (either individually during the school program or collectively during one year), (2) having existing or increasing requirements for teaching non-science courses or topics, and (3) objectives of the state school system that do not include science.

Many states require two years of science in grades 9 through 12; others require only one. In the last two years several states have been considering or have reduced their science requirements in secondary schools to one year. Elementary school requirements are also being reviewed and changed. Requirements in non-science areas are being increased while science areas are being decreased.

In recent years the number of legislation and regulation items has increased. While funds have been provided by states for some of these requirements, in other cases funds have not been provided. Passage of legislation or regulations without funds is frequently another action influencing the curriculum.

3. Policies regarding certification. Certification regulations have continued to be increased in most states, including requirements for teaching science. This action has tended to provide more competent teachers for a number of subject areas and to require more education on the part of the teachers. Many states have inservice requirements for teachers and states with these requirements are increasing; while some

states such as Alaska and Texas provied substantial funding support for inservice requirements, many states do not.

Increased requirements specifically related to science were accelerated in the middle 1960's to the early 1970's. Since 1974, certification requirements have not been increased by many states.

There has been relatively little increase in the amount of college science (quarter or semester hours) taken by elementary school teachers. Changes in current certification patterns are not likely to require increased science content; surveys (Sclessinger et al., 1973; Steiner et al., 1974; Howe et al., 1974) and state data suggest teachers usually do not select much college science course work on their own.

Teaching of science in elementary schools has been a continuing problem. A substantial number of teachers do not enjoy teaching science, do not enjoy science themselves, do not enroll for any course work related to science after they graduate, and do not study science on their own.

4. Policies regarding equality of education opportunity. State activity in this area accelerated rapidly beginning in the middle 1960's and continuing through 1977. Included are provisions for handicapped, minorities, children from low income families, and girls. These requirements have resulted in many programs, program modifications, and facility construction and remodeling.

The impact of these actions on science are not clear. Based on the literature reviewed, it appears science (along with many other programs) has lost funds that were previously available. Where funds have been cut, program changes often identified are (1) reduction in funds for instructional materials (older textbooks, etc.), (2) reduction in funds for laboratory equipment, (3) fewer field trips, and (4) less funds for inservice education.

5. Policies affecting selection and purchase of textbooks and other instructional materials.

States differ extensively on the control exerted over textbook selection and other instructional materials. In general, relatively few states have a minimum support level for material expenditure as they do for teacher salaries. The lack of such support or required spending with increased requirements in other areas has meant that material expenditures frequently increase when funds are available and decrease rapidly when funds are not as readily available. During the late 1950's and through much of the 1960's funds were available to many school districts so material purchases expanded. Since the early 1970's many schools have been in a cycle of very tight funding resulting in reduced expenditure for materials in many districts. Surveys suggest science textbooks are not being replaced as rapidly in 1975 as they were in the late 60's.

In general, states do not exert much control over purchase of non-print instructional materials; this is probably due to the historical heavy emphasis on print materials in schools and the feeling in some states that if you control the selection of print materials you control a substantial part of a child's education.

Control of textbooks and other print material has tended to become less restrictive in a large number of states during the past two decades. The availability of a greater variety of instructional materials has also tended to reduce the limiting effect of adoption procedures in several states. Two exceptions to this trend should be noted. These are (1) concern for "equality" in materials (primarily related to race and sex) and (2) concerns of various consumer groups.

6. Policies related to minimum competencies and accountability.

These are areas in which states have substantially increased their influence in the past two decades. The accountability programs were initiated in most states beginning in about 1965 to comply with Federal program requirements. As states developed plans, programs, and capacities for Federal programs they have extended their interests and activities to state and local programs. Some states have had state-wide testing programs for many years, however, the interest in minimum competencies for graduation from secondary schools developed during the late 1960's and early 1970's. The number of states that have such requirements is increasing each year.

These state efforts can have a positive or negative influence on science education depending on whether science is or is not included in areas emphasized by state programs.

In general, science has not been included in first efforts by most states. Reading, mathematics, and communication have usually been the first areas to receive attention. Focusing on other areas of the curriculum has tended to reduce emphasis on science in statements of goals and objectives; it has probably also reduced time, personnel, and money allocations to science. Comparison of state programs which have focused broadly on the curriculum (such as Oregon) with state programs that have focused on individual areas of the curriculum indicate the latter approach encourages increased fragmentation of the curriculum.

These areas are discussed more extensively in another section of this report.

The above examples indicate areas in which states have exerted influence (control) and areas in which they are continuing to be active.

Wirt (1977) reported an analysis of state authority for 1972-73 on 36 areas of educational policy and on centralization of authority.

The scale (0-6) used is presented below.

Centralization is conceptualized as a variable that ranges from full state decentralization at one end of a continuum to full state centralization at the other end. There are seven logical categories of centralization on which a given school policy might be judged, as follows:

0. Absence of State Authority. The state constitution, laws, and regulations contain no reference to an exercise of authority on a given policy matter. Conceptually, this means that the local school is free to act or not--the epitome of local autonomy unfettered by any state influence. For example, the local school decides whether to treat the birthday of Martin Luther King, Jr., in any special way.

1. Permissive Local Autonomy. Policy is devised and administered by the local educational authority (LEA) without reference to state goals or supervision and the LEA need do nothing. The state is permissive about the goal of policy and about providing assistance to implement that goal. The key word in state authorization is may (what the LEA "may" do). For example, "love of country" is indicated as a desirable curriculum goal but nothing more is said about its meaning or state support of it.

2. Required Local Autonomy. The specifications are the same as in Permissive Local Autonomy, but the district must do something about the policy. For example, the LEA must provide some kind of unspecified course in civic training.

3. Extensive Local Option under State Mandated Requirements. The state sets broad guidelines for service or assistance that permit the LEAs a considerable number of options. The state sets the goal of policy but lets the LEA implement it with but few constraints. For example, a particular curriculum goal may be met by selecting one of five kinds of civics courses.

4. Limited Local Option under State Mandated Requirements. The State sets extensive and detailed guidelines for service or assistance, which the LEAs must administer with little option. The state uses the LEA to administer the state goal within tight (but not absolute) control. For example, the length of the school year will be from 160 to 170 days.

5. No Local Option under State Mandated Requirements. The LEA "must," "shall," or "will" (key words in law) provide a service or state requirements with no variation. There is no leeway for the LEA to do anything other than what is mandated. For example, the number of years of service before a teacher is eligible for tenure is specified.

6. Total State Assumption. The state exercises full control over provision of policy service, with no LEA involvement in providing money, service, veto, or representation. In short, the state undertakes the educational service in its entirety. For example, the state provides schools for the blind.

Such a scale of centralization does not permit fine calibration, It does not, for example, indicate beforehand the exact line between "limited" and "extensive" local option (points 3 and 4 on the continuum). Rather, it permits only a rough categorization of any law or set of policy requirements (Wirt, 1977).

Listed in Table 8, p. 127 are the mean centralization scores for each state. These scores were derived by Wirt and his students from data obtained from the states. Table 9, p. 127 lists the centralization scores of states within specified intervals. Figure 1, p. 128 lists the distribution of the states. Table 10, p. 129 lists the centralization scores of the states on 36 educational policy areas.

While there are some differences between these findings and the current situation (note: state control of equal educational opportunity), substantial change has not taken place. It is interesting that correlations of state rankings of 48 states on a number of items such as state support of local schools, instructional salaries, and selected types of regulations correlate between .6 and .9 for items checked for the years 1958-1973 (correlation analyses completed on selected data by Howe, 1977 and by Wirt, 1977). State rankings generally do not change rapidly.

TABLE 8 (Wirt, 1977)

SCHOOL CENTRALIZATION SCORES, BY STATES, 1972

State	SCS	State	SCS	State	SCS
Alabama	4.67	Louisiana	3.19	Ohio	3.65
Alaska	3.38	Maine	3.09	Oklahoma	4.91
Arizona	2.91	Maryland	3.56	Oregon	4.30
Arkansas	3.57	Massachusetts	2.73	Pennsylvania	3.75
California	3.65	Michigan	3.85	Rhode Island	3.21
Colorado	3.79	Minnesota	4.10	South Carolina	4.61
Connecticut	2.68	Mississippi	3.93	South Dakota	3.08
Delaware	3.15	Missouri	2.84	Tennessee	3.48
Florida	4.19	Montana	3.47	Texas	2.88
Georgia	3.24	Nebraska	3.81	Utah	3.42
Hawaii	6.00*	Nevada	2.84	Vermont	3.17
Idaho	3.26	New Hampshire	3.13	Virginia	3.88
Illinois	3.32	New Jersey	3.87	Washington	4.37
Indiana	3.90	New Mexico	3.79	West Virginia	3.94
Iowa	3.80	New York	3.63	Wisconsin	3.62
Kansas	3.38	North Carolina	3.80	Wyoming	1.86
Kentucky	3.90	North Dakota	2.89		

Mean = 3.59; Standard deviation = .56

* Out of Hawaii's royal heritage, all authority is centralized. There are no local districts.

TABLE 9 (Wirt, 1977)

STATES WITH CENTRALIZATION SCORES WITHIN SPECIFIED INTERVALS

SCS Interval	States*
5.00 +	Hawaii (6.00)
4.50-4.99	Oklahoma (4.91), Alabama, South Carolina
4.00-4.49	Washington (4.37), Oregon, Florida, Minnesota
3.75-3.99	West Virginia (3.94), Mississippi, Indiana, Kentucky, Virginia, New Jersey, Michigan, Nebraska, Iowa, North Carolina, Colorado, New Mexico, Pennsylvania
3.50-3.74	California (3.65), Ohio, New York, Wisconsin, Arkansas, Maryland
3.25-3.49	Tennessee (3.48), Montana, Utah, Kansas, Alaska, Illinois, Idaho
3.00-3.24	Georgia (3.24), Rhode Island, Louisiana, Vermont, Delaware, New Hampshire, Maine, South Dakota
2.50-2.99	Arizona (2.91), North Dakota, Texas, Missouri, Nevada, Massachusetts, Connecticut
Under 2.50	Wyoming (1.86)

* For each interval the highest SCS is given in parentheses and the other states are listed in descending order within that set.

FIGURE 1

School Centralization Scores (Wirt, 1977)

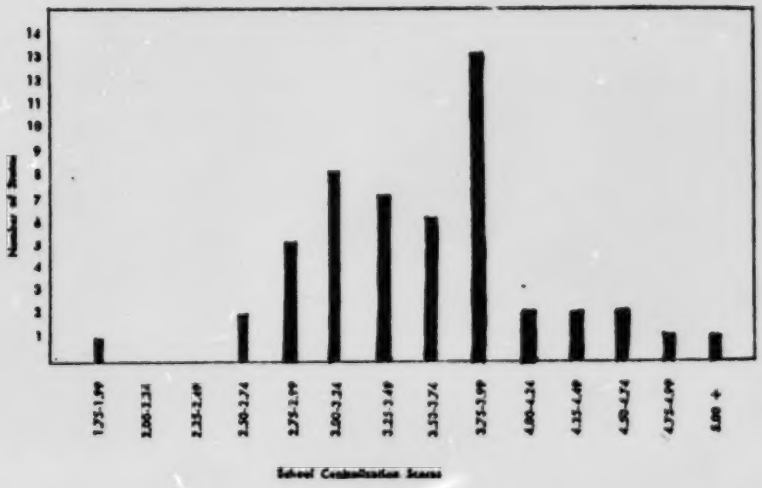

TABLE 10

SCHOOL CENTRALIZATION SCORES ON THIRTY-SIX VARIABLES, BY REGIONS AND SUBREGIONS (Wirt, 1977)

VARIABLE	NORTHEAST	NEW ENGLAND	MID-ATLANTIC	SOUTHEAST	MIDWEST	GREAT LAKES	PLAINS	WEST	SOUTHWEST	MOUNTAIN	FAR WEST	MEAN FOR ALL STATES
Accreditation	-3.90	4.74	-2.90*	+5.70*	4.58	-4.07	+4.94	-3.92	+5.13	-4.30	-2.81	4.50
School calendar	4.21	4.09	+4.35	-3.91	+4.38	4.20	+4.51*	-3.90	-3.68	-3.28	+4.37	4.09
Certification	-4.80	-4.44	5.24	+5.73	5.55	+5.76	5.41	+5.77*	+5.82*	5.67	+5.74	5.49
In-service training	-1.63	-1.67	-1.60	+2.59	-1.74	+2.37	-1.29	+2.31	+3.00	2.00	+3.18	2.09
Salary schedule	-3.14	-2.92	3.40	+4.32*	-2.70	+4.59*	-1.36*	-3.06	-3.00	-2.60	+4.00	3.29
Personnel policies	4.24	+4.59*	-3.82	-3.86	+4.44	+4.61	+4.32	4.13	+4.84*	+4.56	-3.95	4.17
School plant	+3.71	3.51	+3.95*	+4.18*	-2.46*	-2.96	-2.10*	-3.16	-2.08	3.34	+4.84*	3.36
School construction and equipment	+4.09	-3.57	+4.71*	-3.33	+3.92	3.78	+4.02	3.75	-2.00*	+5.63*	3.77	3.76
Safety and health standards	4.23	-3.92*	+4.59	+4.92*	4.35	-3.60	+4.89*	-4.04	+4.98*	4.52	-3.21	4.37
Grade organization	+3.81	-3.08	+4.68*	+4.01*	3.37	+3.93	-2.96	-2.57*	-2.65	-1.55*	+5.06*	3.38
Promotion requirements	-0.50*	-0.00*	1.10	+1.45	1.32	+1.96	-0.86	+1.47	+2.25	-0.20*	+1.50	1.21
Course or credit load	+2.89	-1.55	+4.50*	-1.89	-1.87	-0.60*	2.79	+3.83*	+5.50*	-2.40	+3.25	2.69
Pupil records	3.80	-3.11	+4.63*	3.83	-3.16	-3.01	-3.26	+4.00	-2.46	+3.95	+5.07*	3.71
Textbooks	-3.91	-3.52	4.38	+5.03*	-3.78*	-3.52*	-3.97	+4.57	+5.09*	-4.00	+4.69	4.35
Curriculum	-3.97	4.44	-3.40	+4.78*	4.32	-4.22	4.38	4.50	-3.70	4.45	+4.70	4.41
Extra curricular activities	-1.45	-1.58	-1.30*	+2.66	+3.34*	+3.60	+3.15	2.46	2.45	+2.92	-1.89	2.50
Library	3.59	3.47	+3.73	-3.06	+4.40*	+4.29*	+4.48*	-3.08	-3.00	+3.99	3.57	3.51
Guidance and Counseling	-2.60	-2.52	-2.70	3.14	+3.65	+3.54	+3.73	3.16	-2.87	+3.73	-2.95	3.15
Vocational education	+5.09	+5.12	5.04	+5.49*	-4.40*	-3.77*	4.84	-4.65	5.01	-4.12	-4.40	4.89
Adult education	3.73	3.58	+3.90	+4.34*	-2.86*	-2.62	-3.03	3.61	+4.23	-2.45*	+4.25	3.63
Special education	4.97	4.93	5.01	+5.38*	-4.82*	-4.63*	4.96	5.14	+5.28*	5.23	4.99	5.09
Experimental programs	+2.50	-1.83	+3.30	+3.54*	-1.72	+3.73	-0.28*	-1.43*	-0.95	-1.32	+2.75	2.24

TABLE 10 (Continued)

VARIABLE	NORTHEAST	NEW ENGLAND	MID-ATLANTIC	SOUTHEAST	MIDWEST	GREAT LAKES	PLAINS	WEST	SOUTHWEST	MOUNTAIN	FAR WEST	MEAN FOR ALL STATES
Pupil-teacher ratio	3.08	-2.87	+3.33	+3.67	+3.92*	+3.64	+4.12	-2.02*	-1.25	-2.10	+3.69	3.11
Attendance requirements	-4.16	-3.51*	+4.94	+4.98*	-4.33	-4.66	-4.30	+4.95	-4.04	4.67	+5.68*	4.64
Admission requirements	-3.15	-2.31*	+4.15	+4.34	+4.03	+5.12*	-3.25	3.73	+4.11	2.87	+4.04	3.82
Graduation requirements	-3.87	-3.46	+4.37	4.20	-3.67	-3.80	-3.58	+4.40	+4.80*	-3.06	+5.37*	4.06
School district organization	-2.19*	2.12	-2.26	+4.17	+3.81	+4.03	3.66	+3.93	+4.00	-2.00	+5.25*	4.06
Equal educational opportunity	-2.37*	-1.90*	-2.93	3.70	+3.53	+5.27*	-2.29	+3.60	-2.61	-1.90	+5.63*	3.34
Objectives	-2.14*	-2.58	-1.60*	+3.67	+4.21	+5.30*	3.43	3.50	+4.25	3.50	-3.00	3.41
Pupil transportation	-4.17	-3.96	4.42	4.44	-4.12	4.20	-4.06	+4.56	-3.45	+4.67	+4.91	4.34
Financial records	3.60	-2.61*	+4.79	+4.77	-4.00	-3.30	+4.50	+4.55	+5.34*	+4.93*	4.15	4.26
Accountability	+3.37	3.22	+3.53	+4.02	3.10	3.11	3.10	-2.30	+4.25	-1.20	-1.37	3.14
Evaluation	+3.21	-2.00	+4.67*	-2.81	+3.51	+3.20	3.73	-2.56	+4.25	-1.20	-2.34	2.99
Per pupil expenditure	-1.44*	-1.71	-1.12	2.44	+3.08	+3.19	+3.01	+2.71	+4.22	2.34	-1.50	2.45
Bonds	+1.07	-0.00*	+2.35*	0.50	0.64	-0.00*	+1.09	-0.17*	0.65	-0.00*	-0.00*	0.56
Revenue	-3.12	3.53	-2.62	+4.31	3.62	+4.18	+2.26	-3.28	-3.19	-3.08	+4.44	3.57
Mean	3.27	3.00	3.59	3.87	3.52	3.67	3.41	3.47	3.62	3.16	3.79	3.59

Notes: The scores for the Pacific region are omitted from this table because of the unusual deviation of Hawaii, one state of a two-state set. The scores for the region are included, however, in all reports of means for all states.
- = less than mean SCS for all states by 0.20
+ = more than SCS for all states by 0.20
* indicates a "t" value significant at less than .15.

As Figure 1, p. 128 illustrates, there are substantial differences among the states. There appear to be three patterns of states regarding centralization patterns: (1) those with substantial decentralization or centralization; (2) those moderately decentralized or centralized; and (3) those that are intermediate.

An examination of Table 10, p.129 indicates policy areas that have been (and generally are) subject to more or less centralization. Among those policy areas that are above average in centralization are textbooks, curriculum, graduation requirements, certification, and programs such as vocational education and special education.

The impact of such centralization within each policy area is not clear. Data do indicate, however, that there are differences between and within states and that many of these differences are due to the absence or presence of regulations. Regulations regarding special education, career education, minimum competencies, inservice education, secondary school graduation requirements, teacher certification, etc. clearly influence science education programs. The amount of funding provided by the state per pupil, the percentage of the funding provided by the state, the procedures for providing the funds (block or categorial, direct or through proposals, etc.), and the way decisions are made within the state also impact on science education.

Data examined for this review suggest the role of the state is more important than commonly thought; indeed, the influence of the state appears to be growing. While extensive policy analysis related to science education is beyond the scope of this review, the impact of state action on local programs is clear. Materials reviewed from various states indicated definite impact of state action on science programs. Some examples can be cited:

(1) impact of curricular requirements in states such as Vermont, Delaware and Virginia that will result (or may have by now) in less time for science instruction or fewer students enrolled in science courses; (2) impact of state adoption textbooks lists on selection of materials that are not in textbook form such as modules, units, etc; (3) use of Federal revenue sharing funds in non-science areas; (4) provisions for state supported inservice education, such as Texas and Alaska; and (5) use of state achievement tests (including science) in various states.

Since adequate finances, adequate staff, and stability of financial support appeared frequently in needs for quality programs, a brief examination of trends in financial support is included.

1. Percentage of financial support of schools from Federal and state sources increased from 1955 to 1976.

2. Percentage of financial support of schools from local sources decreased from 1955 to 1976.

3. States differ substantially on both sources of funds and expenditures per pupil.

4. Their are also substantial differences within individual states. These differences have a profound influence on programs.

5. State categorical aid programs have usually followed the passage of Federal categorical aid programs.

6. Federal support for science education was increased from 1955 to the late 1960's (1968 or 1969).

7. Federal support for science education has declined since the late 1960's.

8. State support for science curriculum development and inservice education appears to have declined since the 1960's.

9. Inflation and reduced enrollments are requiring many districts to take actions based on the local financial situation. Major financial reform for school support is needed at the state level if piece-meal action by local districts is to be avoided.

Table 11, p.134 presents the mean school revenue sources for the years 1919 through 1974. The data indicate three patterns: (1) Increasing support from the Federal government beginning primarily in the late 1950's and extending through 1965-66. Since 1966 the percentage of Federal support has fluctuated between 7 and 9%. It is currently about 8%. (2) The percentage of state support has not shown a similar increase since the late 1950's, though the last three years suggest some possible change; the percentage of state support has been nearly flat since the late 1950's. (3) The percentage of local support has shown a general decline.

Table 12, p.135 presents state data for 1973-74. These data show states differ substantially both on their sources of funds per pupil and

TABLE 11

SOURCES AND PERCENT OF SCHOOL REVENUES[1,2]

Year	From federal sources	From state sources	From local sources
1919-20	0.3	13.8	85.9
1929-30	0.4	16.9	82.7
1939-40	1.8	30.3	68.0
1959-60	2.9	39.8	57.3
1960-61	3.8	39.8	56.4
1961-62	4.3	38.7	56.9
1962-63	3.6	39.3	57.1
1963-64	4.4	39.3	56.4
1964-65	3.8	39.7	56.5
1965-66	7.9	39.1	53.0
1966-67	7.9	39.1	53.0
1967-68	8.8	38.5	52.3
1968-69	7.4	40.0	52.6
1969-70	7.2	40.9	51.8
1970-71	7.2	40.0	52.8
1971-72	9.0	37.0	54.0
1973-74	7.5	43.0	49.5

1. National Education Association and U.S. Office of Education , as compiled by the Congressional Quarterly, Education for a Nation, Washington, D.C., 1972, p.9.

2. "A Statistical Profile: Education in the States, 1973-74," Compact, July/August, 1974, p. 14-15.

TABLE 12

REVENUE SOURCES AND
REVENUE AND EXPENDITURES
PER PUPIL 1973-74*

	Revenue Sources for Public Elementary & Secondary Schools			Revenue Per Pupil (ADA)	Increase Since 1972-73	Expend. Per Pupil (ADA)	Increase Since 1972-73
	Federal	State	Local				
Alabama	14.4%	68.0%	17.6%	$ 816	20.2%	$ 716	19.5%
Alaska	16.8%	62.8%	20.3%	2,144[b]	7.7%	1,597[b]	1.3%
Arizona	7.4%	38.5%	54.1%	1,234	14.4%	1,222	25.6%
Arkansas	16.3%	48.8%	34.9%	872	16.1%	773	17.5%
California	6.7%	42.1%	51.2%	1,614	15.2%	1,198	14.1%
Colorado	7.3%	35.3%	57.4%	1,324	6.1%	1,075	7.3%
Connecticut	3.1%	23.1%	73.8%	1,550	3.3%	1,295	4.4%
Delaware	6.6%	69.7%	23.7%	1,710	12.6%	1,388	10.6%
D.C.	11.4%	—	88.6%	1,884	7.8%	1,490	10.1%
Florida	8.7%	57.1%	34.2%	1,132	6.3%	962	2.2%
Georgia	12.0%	55.0%	33.0%	948	13.1%	869	8.4%
Hawaii	8.2%	88.8%	3.0%	1,448[b]	0.1%	1,027[b]	--4.1%[c]
Idaho	11.1%	43.3%	45.6%	968	9.1%	812	7.5%
Illinois	5.9%	40.0%	54.1%	1,631	8.2%	1,228	9.5%
Indiana	5.1%	32.7%	62.2%	1,151	2.3%	890	1.3%
Iowa	4.9%	35.3%	59.7%	1,183	0.6%	1,116	5.6%
Kansas	8.0%	31.4%	60.5%	1,249	8.1%	1,037	11.1%
Kentucky	13.8%	55.2%	31.0%	890	2.7%	727	3.9%
Louisiana	14.0%	56.0%	30.1%	1,045	1.4%	949	2.3%
Maine	9.3%[a]	35.0%[a]	55.7%[a]	986[a]	4.7%[a]	884[a]	4.7%
Maryland	6.2%	47.1%	46.7%	1,769	9.7%	1,322	11.3%
Massachusetts	5.2%	24.2%	70.7%	1,305	5.9%	1,136	3.1%
Michigan	4.0%[a]	50.0%[a]	46.0%[a]	1,309[a]	8.7%[a]	1,260[a]	8.7%[a]
Minnesota	4.7%	58.1%	37.1%	1,497	3.7%	1,201	3.5%
Mississippi	24.5%	52.5%	23.0%	908	11.4%	787	13.1%
Missouri	7.6%	35.9%	56.4%	1,192	5.8%	963	8.4%
Montana	8.5%[a]	40.0%[a]	51.5%[a]	1,096[a]	7.7%[a]	1,015[a]	7.6%[a]
Nebraska	7.9%	20.8%	71.3%	1,051	9.0%	957	7.6%
Nevada	6.1%	41.8%	52.1%	1,213	11.0%	1,032	7.6%
New Hampshire	3.0%	7.4%	89.6%	1,082	6.4%	909	3.2%
New Jersey	5.7%	28.7%	65.6%	1,638	7.3%	1,432	10.8%

*"A Statistical Profile: Education in the States, 1973-74," Compact, July/ August, 1974 p. 14-15.

TABLE 12 (Continued)

	Revenue Sources for Public Elementary & Secondary Schools			Revenue Per Pupil	Increase Since 1972-73	Expend. Per Pupil (ADA)	Increase Since 1972-73
	Federal	State	Local				
New Mexico	16.0%	64.4%	19.6%	1,036	0.9%	939	9.7%
New York	4.9%	39.1%	56.0%	2,118	9.6%	1,809	9.7%
North Carolina	10.5%	68.7%	20.8%	1,131	13.0%	900	10.6%
North Dakota	9.1%	43.9%	47.0%	1,157	16.0%	947	11.3%
Ohio	7.3%	34.3%	58.5%	1,137	7.1%	1,009	5.8%
Oklahoma	9.3%	44.8%	45.9%	962	5.7%	835	8.7%
Oregon	4.1%	24.4%	71.5%	1,373	8.0%	1,058	4.2%
Pennsylvania	6.8%	49.7%	43.5%	1,515	8.8%	1,247	7.0%
Rhode Island	8.1%	36.4%	55.5%	1,324	6.4%	1,250	5.6%
South Carolina	15.8%	57.4%	26.8%	992	7.5%	856	7.1%
South Dakota	14.9%	13.0%	72.0%	1,069	12.2%	921	10.4%
Tennessee	13.1%	45.1%	41.8%	900	6.3%	804	8.5%
Texas	11.0%	47.5%	41.5%	1,060	6.6%	898	6.9%
Utah	8.2%	56.8%	35.0%	1,021	10.4%	816	7.2%
Vermont	6.1%	33.0%	60.9%	1,411	1.4%	1,308	1.5%
Virginia	10.4%	36.7%	52.8%	1,188	7.9%	1,010	7.3%
Washington	8.7%[a]	56.5%[a]	34.8%[a]	1,366[a]	4.4%[a]	974[a]	4.4%
West Virginia	12.5%	57.5%	30.0%	922	4.9%	871	7.4%
Wisconsin	3.3%	40.0%	56.8%	1,373	5.0%	1,200	5.8%
Wyoming	11.1%	36.7%	52.2%	1,139	—6.1%[c]	999[a]	—7.1%[a]
Total U.S.	7.5%	43.0%	49.5%	$1,344	8.2%	1,121	8.3%

NOTES: NA—Not Available. NC—No Change. [1]—The difference between revenue and expenditures per pupil is due largely to the inclusion under revenue of receipts for repayment of long-term debt and the exclusion under expenditures of payments for non-day school programs, interest and capital outlay.

[1]—Includes supervisory and administrative personnel, as well as teachers. a—Estimated. b—Reduce 30% for Alaska and 19% for Hawaii to adjust for differences in purchasing power. c—Decrease. d—Median salary. e—Excluding kindergarten.

the revenue and expenditures per pupil. While these figures illustrate between-state differences, they do not represent within state differences. Data examined in the process of preparing this review indicate marked differences among many communities within states. Substantial effort is being expended by many states to look at policies regarding financial support for schools and to consider modification of many state support programs.

Since the late 1950's it appears that categorical state funds have frequently followed the pattern of Federal funds. The present stage of federal participation in education began as the United States emerged from World War II (Milstein,1976). While the primary funding from 1945 to 1952 was to aid veterans education, the last 20-25 years has changed to programs with substantial funding and impact on elementary and secondary schools including science education.

Some of the legislation and the patterns of legislation are important in reviewing changing patterns and needs in science education. A few of these will be identified.

1. The NSF Teacher Institute Program

This progam began development of institutes for teachers in 1953. The institute program reached a high point in 1968. These institutes first concentrated on subject matter competency, and later some included pedagogy. In recent years, implementation of curricula was a major focus.

2. The NSF Course Improvement Program.

This program, which started in 1956, spent about 100 million dollars during the first 11 years. Estimates of support for 1967-1975 were approximately 65 million dollars (Welch, 1976; The National Science Foundation and Pre-College Science Education: 1950-1975, 1976.) A substantial amount of these expenditures were for elementary and secondary school materials. Since 1975 the size of the program has been reduced substantially.

3. The National Defense Education Act of 1958.

This program promoted the improvement of educational programs in specific areas; science was one of the identified areas. The act provided funds for (1) equipment, (2) support for guidance, counseling, and testing, (3) funds for inservice education, and (4) funds for research on teaching aids. The provisions of the act were changed, and funds for science were substantially reduced as provisions of the act changed.

4. The Vocational Education Act of 1963

This act increased federal support for vocational education approximately fourfold. This and other legislation in the early 1960's provided strong support for increased emphasis on vocational and career education. Legislation and support has continued to expand these programs. Many courses offered by the schools contain substantial science (and mathematics and social science) content, but are seldom included in science course enrollment counts. If these courses were included in science enrollments, there would be a substantial increase in percentage of enrollment of

students in science courses. An examination of the literature contained in the ERIC data base for 1966-76 related to vocational and career education courses of a scientific and technological nature indicate very few authors that are usually associated with science education. Documents reviewed revealed little, if any, planning between those responsible for programs related to science education and vocational/career education at the Federal and state levels. Some cooperative planning appears to be evident in local curriculum guides, curricula, and courses of study reviewed.

5. The Economic Opportunity Act of 1964.

This act focused on culturally deprived and dropouts. It was part of a substantial effort to improve economic and educational equality. The act affected the schools at both the elementary and secondary education levels. Many students retained in school by this program have taken some science in secondary schools. They usually enrolled in general science, earth science, and biology. Relatively few have enrolled in chemistry or physics.

6. The Elementary and Secondary Education Act of 1965.

This act provided massive support for the schools. Provisions of the act included funds for children from low income families, planning, research, leadership, handicapped children, and bilingual children. This act, which has been continued, has provided substantial money (over $1 billion per year) for the areas covered by the act. In general, specific curricular areas have not been identified. Rather, the emphasis has been on groups to be served or types of services to be provided.

The pattern indicates growing Federal support in total dollars for science education from the late 1950's through 1968. Beginning in 1964 and 1965 Federal legislation was passed that stressed the disadvantaged, career and vocational education, equality of educational opportunity, bilingual education and others. While these funds could be used for some science education related purposes, in general they were not. In addition to the focus of the funds, many of the Federal programs required matching money from local schools. Thus, funds were frequently used for areas other than science education. A third factor related to funding involved continuation of support for established programs. Attempts to obtain materials from ESEA Title III programs by ERIC/SMEAC from 1968 through 1972 indicated that about 80 to 85% of the programs were discontinued when Federal funds were withdrawn.

Reduced support from the National Science Foundation and relatively small amounts of money from the Office of Education, the National Institute of Education, and other Federal agencies have been the pattern for science education since the late 1960's. Since 1968 the financial assistance priorities established by the Federal programs and essentially followed by state and most local schools have placed less emphasis on support of science education. This change in emphasis is also evident in recent and current state plans for minimum competencies as being developed by many states--science is seldom included in the first evaluation efforts. It has not even been included in a number of planning documents.

The presence or absence of Federal programs and funds for science education are clearly evident in state and local school programs. During the past 20 years Federal programs and funds have helped improve state efforts in planning and in coordinating science education efforts. The impact of Federal (and also state) funds on program development have often been reduced by lack of adequate lead time for people to become aware of available funds, late funding, lack of continued funding support, and problems of matching fund requirements (What is deleted from the school program to obtain the matching funds?).

Many points of view have been raised regarding the use of block aid and categorical aid. If the purpose is to allow the schools to use funds in ways determined by them, block aid leaves the decision to the state or local unit. If the purpose of the funds is to accomplish a defined objective, the use of categorical aid is more likely to be successful. A review of recent funding legislation indicates a reduction of categorical Federal aid for science education since the late 1960's; based on past patterns of state and Federal funding it is not likely that many states will give science a high priority since the Federal legislation does not.

As shown in Table 11, p.134 the percentage of revenue for local aid being provided by the local schools has been generally decreasing. Table 12, p.135 shows there are many differences among the states in the percentage of funds provided by the local district. Local control of schools is one of the characteristics of American society that many

people want to preserve. Raising local revenues to provide for education has not been defended strongly; indeed, the pattern of support for public schools indicates a general decline in the percentage of local revenue for support of local schools. Problems of schools with a high percentage of support from local revenue have been documented in many reports and publications. Among the problems are (1) inequality of the tax base, (2) differences in percentages of homes with school-age children in various communities, (3) differences in increases or decreases of student enrollment during a fiscal year, (4) differences in fixed cost requirements for different communities, (5) differences in educational needs and problems in different communities, (6) the effect of voter apathy on school levies and bond issues, and (7) the effect of special interest groups on school levies and bond issues.

Many surveys and articles indicate that central cities and low socioeconomic areas frequently have the poorest facilities and a greater need for better instructional materials. However, for various reasons, funds are not voted to provide for their needs. With declining enrollment, economy measures may be taken by a local district; examples of such actions are elimination of supervisors, reduction in material purchases, reassignment of teachers to non-certified or minimum competency areas, increase in number of course preparations, reduction of laboratory work, reduction of inservice education, and increase in pupil/teacher ratios.

All of these actions have occurred and will probably occur with increasing frequency as enrollments drop. While some economies may be needed, different communities face different problems.

From analyses of school financing, schools that currently have a low tax base per pupil and that depend heavily on local revenue will be

most subject to problems previously described. With the increasing mobility of the American population, especially within the states, increased state support of schools for the educational program needs to be carefully examined.

Wirt (1977) believes if the locus of reform is the district, a sucessful effort is only a "skirmish" victory because local politics are episodic. The frustration of local reforms efforts is high; hence, he recommends that major reform efforts be accomplished at the state level. Our analyses of financing of public education support his position.

COST EFFECTIVENESS OF SCIENCE EDUCATION INSTRUCTION

A review of the literature revealed very few studies related to the cost effectiveness of programs. A review of research related to instruction included in the ERIC data base for 1966-76 and included in reviews of research published by ERIC/SMEAC that cover the years 1963-75 yielded relatively few studies that are apt to provide substantial differences in cost. Analyses of local school budget summaries for 11 states showed that the major costs to a school are (1) teacher salaries, (2) building construction payments, (3) operation and maintenance of the building, (4) transportation (primarily to and from school), (5) administrative and staff salaries, and (6) instructional materials and supplies.

All but items 1 and 6 are fixed costs unless the program is conducted in a different building, in no building, or involves transportation. Item 1, teacher(s) salary, is usually the major cost variable. The basic items that would affect the cost of the teacher would be (1) the pupil/teacher ratio , (2) where the teacher was on the salary schedule, and (3) amount of teacher and staff time required for instruction and planning. In most studies analyzed, instruction involved a single teacher or a few teachers. Reports seldom included the salary level of the teachers; any substantial difference in control and experimental teacher salaries or fixed costs in the school would offset nearly all material cost differences in the vast majority of the studies.

Instructional material costs represent a very small percentage of most school budgets--surprisingly small considering the school investment

in the other five areas. To demonstrate any substantial cost effectiveness of one successful program over another would require manipulation of staffing patterns and/or building use. Research that manipulates these variables is needed and current technology (televsion, computer, etc.) can provide alternatives not available in the 1950's and 1960's.

V. NEEDS ASSESSMENT EFFORTS

Documents reviewed for this section were identified by a search of the ERIC system data base, a search of the National Institute of Education library, a search of Dissertation Abstracts International, review of reports before various US House and Senate committees, and by contacting state departments of education. The results of this review will be presented first in terms of general educational needs, then needs specifically related to science education.

GENERAL EDUCATION NEEDS

A review of the literature reveals a set of recurring needs. The sources of these needs include documents that are national in origin and scope, documents that are regional in nature, and documents that involve state levels. State activities in needs assessment were mandated with guidelines charging the state education agencies with administrative responsibility for ESEA Title III programs (Indiana Needs Assessment Project..., 1971). Among the guidelines was the following:

> The State plan shall identify the critical educational needs of the state as a whole and the critical educational needs of the various geographic areas and population groups within the state, and shall describe the process by which such needs were identified. The process shall be based upon the use of objective criteria and measurements and shall include procedures for collecting, analyzing and validating relevant data and translating such data into determinations of critical educational needs.
>
> Section 118.8, U. S. Office of Education regulations for administering ESEA Title III programs.

The following are statements that summarize the needs as reflected in the literature.

1. A major need, identified in nearly every pertinent document reviewed, is for improved financing for education.

2. Basic skills, particularly including reading, mathematics, communication and language arts skills, and fundamental knowledge in such areas as science, social science, and other discipline areas, were among the top needs identified in a majority of cases.

3. Equal educational opportunity for females, blacks, Indians, people of Hispanic origin, migrants, inner city students, rural students, and bilingual students was identified as a major need.

4. Within the last decade, concern has increased for accountability in education. This includes both accountability for learning (such as performance contracting, competency based education, and minimum performance requirements for graduation) and program management (such as PPBS, management by objectives, management information systems, and school consolidation and reorganization).

5. Concern for vocational or career skills and knowledge has become increasingly important.

6. Life-long learning is of increasing importance at the state level; this implies educational concerns beyond the level currently seen as the limit for formal education.

7. Desegregation and related educational problems, including financing, is a concern in many school systems.

8. Concern for exceptional children and special education, especially reflecting the needs of the handicapped, continues; there appears to be increasing concern for the gifted.

9. A number of states indicate concern for programs to decrease school dropouts.

10. Dealing with the student as an individual, in terms of developing a positive self image and individualizing instruction, is of increasing importance.

11. Discipline and student management is a concern reflected in many cases.

12. Improved health-physical fitness programs is seen as an increasing need.

With respect to the preceding list of identified needs, some general comments are in order. The sources of information leading to the needs identified most often originated with legislation, with surveys of school system or states, or with committees or conferences involving knowledgeable

persons. Rarely did the basis for need identification involve research, other than a survey or opinionaire. In only a very few cases was science included as a result of collecting information from persons in a system-wide or statewide survey. It appears that the point of access to influencing educational concerns is legislation. This will be considered in more detail in the section dealing with needs related to science education.

Financing

The cost of education is clearly one of the most important concerns throughout the nation today. In California, a sample of 2000 parents, teachers, principals, superintendents and school board members rated financing the biggest single problem facing the schools ("California Survey Results," Education Training Market Report, 1975). Similarly, in a report by the Colorado State Department of Education, school districts in the state rated financing among the top operational priorities for their respective schools (Priorities in Education..., 1976). A survey of over 400 school board members, their spouses, board secretaries, and school superintendents in Iowa reported that the loss of state funds due to declining enrollments was the most pressing problem in Iowa education ("Education Survey," DPI Dispatch, 1976). Oregonians indicated the same concern for financing in a survey conducted by the Oregon State Board of Education which involved holding "Town Meetings" throughout the state (Wright, 1970).

Financing is not a concern limited by state boundaries. In June, 1970, questionnaires were sent to all chief state school officers, executive officers of state boards of higher education, state board associations, and state education associations. Responses were received from 46 states. With respect to finances, the report notes:. "Outstanding in their dominance of the reporting were issues related to local school district financing"

(Wing, 1971, p. 121). In a later survey of the states, the Education Commission of the States also reports that the states rated school financing at the top of the list of problems facing education (Legislation: Achievements..., 1972). Nor is concern for this problem limited to people directly involved in the educational process. In 1971 a survey revealed that most Americans rated financial crisis as the number one problem in the public schools (Gallup, 1971).

Financing, of course, affects the total school program. When funds are reduced, the program must be adjusted accordingly. This typically means dropping specific courses or programs and reassignment of personnel. When financial support (especially external support) for a particular program is removed, the program rarely survives (Helgeson, 1971c). Because science is usually ranked lower in priority than some other segments of the curriculum, the science program is among those which are influenced earliest by changes in financing.

Clearly, school financing problems are pervasive, persistent, and potentially pernicious.

Basic Skills

Increased emphasis on basic skills is reflected widely in the literature reviewed. The General Assembly of Virginia specifies as the first standard of quality for education achievement in basic learning skills and specifies that minimum educational objectives shall be established in reading, communications, and mathematics skills by September, 1978 (Standards of Quality and Objectives..., 1976). Basic skills are included among the top ten goals listed for education in Massachusetts (Educational Goals for Massachusetts, 1971). As a result of the data gathered in 1973 for the state of Indiana, the top educational needs identified included increased stress

on higher cognitive skill development and basic mathematics (Indiana Needs Assessment Project, 1974). In Colorado, a survey of school districts within the state revealed that basic skills topped the list of program priorities for students. This concern was especially predominant among those districts with the most progress in educational accountability (Priorities in Education..., 1976).

These needs are not limited to the state level as can be seen by the Appalachian Education Project Technical Reports (Mertens and Bramble, 1976a, 1976b) and by the Eight State Project (Designing Education for the Future..., 1969). Moreover, they are a particular concern for ethnic and minority groups such as the Hispanos ("Hispanic Youths...," NAEP Newsletter, June, 1977; Fernandez et al., 1975) and the American Indians (Bass, 1971). In a synthesis of 99 research studies related to urban disadvantaged pupils, McCloskey (1967) noted that one of three major needs was to aid pupils in developing reading, writing, and communication skills. Similar concerns can also be deduced at the national level from the Elementary and Secondary Education Act, Title III, Title IV, and Title V, from the National Defense Education Act, and from the National Assessment of Educational Progress ("Study Traces Achievement 'Profiles' ", 1977).

As a major need facing education, the basic skills are almost invariably viewed as including reading, mathematics (especially computational skills), communication and language arts skills (both written and oral), and fundamental knowledge in other areas. It is only in this last category that concern for science is indicated, and then only rarely, when the needs are determined by surveys of the population in general. Based upon the fact that much of the activity in science education stems largely from the influence of nationally legislated programs, it appears that the most accessible entry to the educational program in science is through legislation.

Equal Educational Opportunity

Equal educational opportunity was identified as a major need at national, regional, and state levels. The increased mobility of the American population has given rise to a national perspective on education which recognizes this concern on a broad basis (Educational Research: Limits and Opportunities, National Institute of Education, 1977). Equality of opportunity is a need for ethnic and racial minorities (Olson, 1970; Williams and Nusberg, 1973) for females ("Education Survey", 1976), and for both inner city and rural students, who are viewed, in many cases, as facing deprived conditions (Educational Research: Limits and Opportunities, 1977). These needs may vary somewhat from one region to the next; for example, needs specific to American Indians are indicated in the West and Southwest (Bass, 1971), The Hispanic students score below their contemporaries in achievement ("Hispanic Youths...", NAEP Newsletter, 1977; Fernandez et al., 1975), and inner city and rural students may both be deprived, although in somewhat different ways (Educational Research: Limits and Opportunities, 1977; Mertens and Bramble, 1976b). Yet the overall problem is one of extending educational opportunity (Wright, 1970; The Report of the Citizens Commission on Basic Education, 1973), or, it has been suggested as a more viable goal, equal access to appropriate education (Thomas and Harman, 1972).

The implications for science education derive from those for the program as a whole. While the science content involved need not vary markedly, the approach to instruction must reflect cognizance of differing student backgrounds, environments, experiences and language structures.

Accountability/Assessment

Accountability is generally considered to have begun with ESEA Title I in 1965 in which each local education agency was charged with providing an evaluation of program effectiveness with respect to the educationally deprived (Law, 1971). The whole issue of accountability has become closely intertwined with needs assessment and both areas are often grouped together with testing (Ross, 1973a).

Basic causes for accountability pressures are high cost and low pupil achievement (Young, 1971). The old assumption had been that the needs of education were unlimited and, with limited funds available, the problem was to get the most for the money spent. A better approach is to set limited educational needs and then find the most cost effective way to achieve those needs (State Educational Assessment Programs, 1971). However, because achievement can be measured, that is most often what is assessed; within achievement, it appears there is a tendency to measure the lower levels of understanding. As Turnbull says: "If you give a small boy a hammer, he will find that a great many things need pounding." (1971, p.3).

By 1973 some kind of accountability system was require in 23 states. The major types are indicated in Table 13.

TABLE 13

Major Types of Accountability Systems and Number of State Adoptions

Types of State Accountability Systems	Number of State Adoptions
Planning, Programming, Budgeting Systems	7
Management Information Systems	2
Uniform Accounting Systems	4
State Testing and Assessment	13
Evaluation of Professional Employees	8
Performance Contracting	1

(Buchmiller, 1973, p. 4)

The most common requirement was state assessment (13 states) and the most frequently specified component was student achievement (12 states). Eight states specified that the basic academic skill areas be assessed. The pattern of major components within the state assessment programs is presented in Table 14. The most common reason for adoption of state assessment programs, according to Buchmiller, (1973) were the improvement of pupil performance, evaluation of educational programs, and the identification of performance levels in relationship to educational needs.

The effectiveness of the various systems is not clearly supported. House, Rivers and Stufflebeam (1974) in an assessment of the Michigan accountability system, found that the system was not working well and that the strongest support was from the state department personnel who were working with it. The authors strongly discouraged tying financial support to achievement gain scores of students since there was too little evidence to support any relationship between schools, teaching, and achievement, especially when achievement was measured with standardized tests (p. 23).

While 35 states currently have some form of education accountability laws, legislative interest appears to be waning ("Accountability", 1977). Those states having accountability legislation are listed in Table 15 .

Performance contracting was first applied to public schools in 1969. By 1971 over a hundred schools were trying it, mostly in mathematics and reading. Several difficulties attended performance contracting. Standardized tests were often used, many times in instances in which they were inappropriate. A wide variety of diverse intruments (119) were administered, many of which were neither valid nor reliable. And, the tendency persisted to assess only those goals that could easily be measured (Stucker and Hall, 1971). R.R. Anderson (1973) reports the evidence suggested equivocal results

TABLE 14

MAJOR COMPONENTS OF STATE ASSESSMENT PROGRAMS

Characteristics	Number of States Requiring
State educational goals and/or objectives	6
Citizen involvement	1
Performance objectives	7
Achievement testing	12
School program and curriculum evaluation	12
Required performance analysis	2
SEA assistance to LEA's	6
Norm-referenced tests specified	4
Criterion-referenced tests specified	1
Intelligence tests specified	1
Requires non-achievement variables	2
Requires comparative data	6
Specified basic skills	8
Implies other areas	6
Specified grade levels	2
Specified age levels	1
Use of Results for:	
Improvement of pupil performance	5
Program evaluation	10
Identify status and needs	6

(Buchmiller, 1973, p. 7).

TABLE 15

States With Some Form of Accountability Legislation

Alaska	Kansas	Ohio
Arizona	Louisiana	Oklahoma
Arkansas	Maryland	Oregon
California	Massachusetts	Pennsylvania
Colorado	Michigan	Rhode Island
Connecticut	Minnesota	South Dakota
Florida	Mississippi	Texas
Georgia	Nebraska	Utah
Hawaii	Nevada	Virginia
Illinois	New Jersey	Washington
Indiana	New Mexico	Wisconsin
Iowa	New York	

("Accountability," Legislative Review, 1977)

at best, in part because of problems with the evaluation itself. He concludes that the evidence is not strong enough to support performance contracting, apparently a view held by many, since interest appears to be fading.

Interest in performance, on the other hand, persists as indicated by an increase in the number of states with competency-based education and minimal competency requirements for promotion or graduation. Assessment based on performance objectives is being used in some cases to set educational goals and identify needs. An example of this is the Kentucky Educational Assessment Program in which the sequence includes setting general goals, performance objectives, criteria for performance (eg., 50% of students will reach criterion level of 67%), and measuring or testing. In this case a need is identified according to the formula:

> Expected Performance - Actual Performance =
> Results Below Expectation = An Educational Need
> (Kentucky Lepartment of Education, 1975).

More often, the performance objectives are established to determine whether or not the student is to be promoted or graduated. At this time, only Florida has banned the use of "social promotion" and mandates grade promotion based on performance As a logical extension of performance based promotion, the concept of "early out" testing is being implemented in California and under consideration in Florida (Education Commission of the States, "Update IV", 1977). States which have, or are considering, minimal competency requirements are listed in Table 16.

As is the case for basic skills required by state guidelines, science is often not included among the areas for which minimal competencies are required. Some states currently include science (e.g., Michigan, Florida, Virginia) and others are beginning to develop specifications for science (e.g.,New York, Ohio).

TABLE 16

Summary of State Activity in
Minimal Competency Requirements

Legislation	State Board of Education Ruling
California	Arizona
Colorado	Georgia
Florida	Delaware
Maryland	Idaho
New Jersey	Kentucky
Virginia	Maryland
Washington	Michigan
Louisiana	Missouri
	Nebraska
	New Hampshire
	New Mexico
	New York
	Oklahoma
	Oregon
	Rhode Island
	Vermont

Pending Legislation

Alabama	Massachusetts
Arizona	Minnesota
Arkansas	New Hampshire
California	Nevada
Florida	New Jersey
Illinois	North Carolina
Iowa	Ohio
Kansas	Pennsylvania
Louisiana	South Carolina
Maine	Tennessee
Maryland	Texas
	Washington

(Education Commission of the States, June 15, 1977)

Competency or performance based education has both advantages and disadvantages. In the first category is the identification of objectives that help to clarify the intended outcomes of instruction. This clarification also aids in evaluating how well the educational program is doing what it intended, and, if successful, aid in increasing credibility. Finally, carefully defined objectives should aid in the efficiency of education by reducing unnecessary study and decreasing overlapping in programs.

Among the disadvantages is that it tends to limit teaching outcomes to observable behaviors. Process goals involving wide ranges of behavior over long periods of time do not fit well into such a scheme. Another disadvantage is the conception of knowledge being recalled on cue; perceptional and conceptional frames which permit the individual to encounter new experiences do not function by simple retrieval of a single skill or item of information. If the need for broad generalizations to provide building frames for understanding and interpretation is a correct theory of transfer, strictly applied competency based education would negate such transfer. On a practical note, the very task of writing objectives is difficult and time consuming. And, finally, the cost of a competency approach may be greater than that of a more conventional approach (Broudy, 1975, pp. 6-7).

Cawelti (1977) is also concerned with competency based education and considers the following as some of the most urgent caveats of the competency movement:

> • A proliferation of testing: most states are adding an additional testing program on top of SAT, ACT, CEEB, and an already existing standardized testing program in the district (plus NAEP if participating).
>
> • If promotion from eighth grade of high school graduation is to be denied students who do not attain competencies, our country will be reverting to an elitist educational system similar to what existed in earlier years.

> •The tendency toward a serious imbalance in the curriculum as subjects such as art, music, and drama are driven out in the quest for high reading scores.
>
> •The publications of test scores by building may be of more value to real estate agents than educators; invidious comparisons are made and what pride a school may have developed is often lost as this is done.
>
> (p. 2)

In 1973 some type of program management accountability was required in 13 states (Buchmiller, 1973). The majority (7) of these involved planning, programing, budgeting systems (PPBS). Within a year, Hawthorne (1974) reported 34 state adoptions requiring accountability in program management. Of these adoptions, 16 involved PPBS, 5 were management information systems, 5 included management by objectives, and 8 required uniform accounting systems. The concern for cost effectiveness seems clear.

Career Education

Education has always been, to a greater or lesser extent, concerned with preparing students for the world of work. This concern appears to have increased during recent years. Part of this concern may stem from the availability of funds through the Vocational Education Act of 1963, but the widespread evidence in the literature suggests that concern is not limited by, or to, this Act. Virginia lists career preparation as the second in its ten standards of quality and objectives (Standards of Quality and Objectives..., 1976). By 1978, Oregon will require a minimum of 130 clock hours of instruction in career education for graduation from high school (Clark and Scott, 1976). Colorado includes improvement of opportunities in vocational and other career education as one of the program priorities as reported by school districts (Priorities in Education..., 1976). Massachusetts specifies occupational competence as one of its ten educational goals (Educational Goals for Massachusetts, 1971).

Career concerns are included in city and regional as well as in state assessments. Among the specific inservice training needed in the Appalachian region is career counseling, career education and vocational education (Mertens and Bramble, (1976b). Severe weaknesses in the career preparation of high school students are reported by Walberg and Sigler (1975). Responses to a survey of 20 chief personnel managers of 17 Chicago corporations revealed that most believed that less than 40% of the high school graduates were ready for employment with their existing high school backgrounds. Such a problem has existed for some time. Among the seven crucial issues identified as facing the states was vocational-technical education ("Seven Crucial Issues in Education...," 1967). That this is not a narrowly held view is reflected by the fact that Gallup reported, in his fourth annual poll of attitudes toward education, that 44% of the public believes that one of the goals of the schools should be to prepare students to get better jobs. This finding had the highest percentage of agreement of those reported (Gallup, 1972). A large segment of the American public clearly sees education as having a major responsibility for preparing youth for careers.

This implies that science education must reflect concern for and, awareness of, science related careers if it is to be consistent with the public. This also suggests the possible need for increased emphasis on the applications of science rather than exclusively concentrating on basic science.

Lifelong Learning

Increasingly, education is being considered a continuous process rather than a program terminating with a degree or diploma. Michigan reports a task of the existing educational system is to prepare children adequately for college and other continuing education ("A Position Statement on Educational..," 1972). An assessment of Colorado's needs revealed an imperative

for occupational education on a continuing basis for all ages (Olson, 1970). Continuing and adult education were also determined to be needs in the Appalachian region (Mertens and Bramble, 1976b). While many state guidelines and assessments emphasize the need for continuing education related to careers or occupations, several are also concerned with self-development. An example of this is found in the goals for Washington schools which hold that each student should "be committed to lifelong learnings and personal growth" (Washington State Board of Education, 1972, p. 22). The concept of lifelong learning lends support to the point made by Williams and Nusberg (1973) that schools should perhaps become a part of the information management system and perhaps not the only, nor even the major, educational force.

Some implications for science education derive from the work by Rowe (1974a, 1974b) related to fate control. The student who believes that he or she exercises some control over the environment and over the outcomes of existing conditions is more likely to exhibit a willingness to learn from new information than is the student who believes that outcomes are determined by chance with little opportunity of influencing the results. Science education programs provide an opportunity to examine phenomena where alternative answers are reasonable and where "unsure inferences" are appropriate. Such circumstances provide some opportunity for altering the student's perspective relative to fate control (Rowe, 1974b, p. 306).

Desegregation

Surveys of the public often revealed concern for desegregation and related problems. A sample of 2000 people in California listed integration-desegregation as one of the top eight problems facing the schools. The Third Annual Report of the National Council on Educational Research lists

desegregation among the three major problems of education (Educational Research: Limits and Opportunities, 1977). Part of the difficulty appears to be related to costs, part appears related to busing ("Education Survey," 1976). Underlying both concerns is the fact that desegregation is, at least to some degree, a legislated concern. Thus, another difficulty appears to be related to the locus of control of the schools shifting from the local level to the state level or even the national level. In any case, the problem is complex and persistent and must be considered among the most critical educational needs of the states.

Because there are cost and time factors involved in desegregation, an impact on the school program not unlike that of reduced funding may result during the initial phases. The potential implication for science education is, again, that of reduced staff or program resulting from diverted finances.

Exceptional/Special Education

The handicapped student has long been of concern in educational systems; that this is a continuing concern is apparent from existing state guidelines, such as those of Virginia, which require special education programs for students with handicapping conditions (Standards of Quality and Objectives..., 1976). Many states have legislated requirements providing for special education (House Bill 2256, State of Arizona, 1973) and/or regulations which specify that alternative programs be available for students when the educational objectives cannot be met in the regular program (Rules, Regulations, and Minimum Standards, Tennessee State Board of Education, 1976). Recently, more attention appears to be focused on the talented and the gifted student. This appears both in state policies (Standards of Quality and Objectives..., 1976) and in surveys (Priorities in Education..., 1976). With mainstreaming becoming a large scale trend, teachers rate high the need for training for

instructing the exceptional child, with concern for the gifted a high priority (Mertens and Bramble, 1976b).

There are implications for science education in at least two areas related to the exceptional child. The first is in program or curriculum development which provides opportunities for the gifted or exceptional student. The second is for science teacher education, both preservice and inservice, for dealing with such students.

Dropouts

School dropouts are viewed as an important concern at many levels. Programs to prevent or reduce dropouts are in some instances identified as objectives for expenditure of ESEA Title IV funds (Ohio State Department of Education, 1977; "Profiles of Studies 1976-1977, South Carolina State Department of Education, 1977). Unfortunately, dropout rates tend to be higher among those students who are lower in achievement, thus exacerbating the condition (Bass, 1971). Even in cases where overall achievement is above national norms, need for programs for the potential dropout is indicated (State Educational Evaluation..., Kansas State Department of Education, 1970).

Reducing the number of dropouts (in effect, increasing the holding power of the schools) would have an impact on science enrollment. The existing pattern is for higher percentages of student enrollments in grades 9 and 10, during which time most students take general science or biology. Reducing the number of dropouts would thus result in an increase in the percentages of students enrolled in biology and general science. There would not likely be corresponding increases in chemistry or physics enrollments unless there was a marked shift in the pattern of enrollment generally.

Individualization

Williams and Nusberg (1973) cite the "youth revolt" of the 1960's as one of the major factors resulting in new policy needs to deal with students themselves. The trend toward humanism is noticeable in the educational goals and needs reported in the literature. Dealing with the student as an individual has at least two components. Because learning is an individual act, instruction should be individualized to account for student differences (Rowell, 1975). There is also the aspect of the student's self development in terms of personal values, self image, and self fulfillment. It is in this area that increased attention is being paid. Development of personal values is held to be an important goal in several instances (Nyquist, 1974; DePew et al., 1976; Goals and Needs of Maryland Public Education..., 1972), as is self development in terms of a positive self image (Priorities in Education..., 1976; Colburg, 1975). Although there is no evidence that such is the case, the potential exists for conflict between the needs of the student as an individual and the minimal competencies required in some states.

The implications for science education involve both horns of the dilemma. On the one hand (or horn), science offers a high potential for laboratory oriented, student centered learning activities which can be utilized for increasing individualization of instruction. On the other, the development of minimal competency requirements can easily lead to standard levels of achievement demanded for all students with the only individualization being the variation in time needed for accomplishing the specified levels. It appears that care will be necessary to provide for alternative approaches to competency if science instruction is to be individualized.

Discipline

With respect to students, another kind of need is also reported in the literature, the need for dealing with discipline problems. Discipline is listed as one of three major problems of education in the Third Annual Report of the National Council on Educational Research (Educational Research: Limits and Opportunities, 1977). The sample of 2000 people in the California survey also listed discipline as a problem, along with the possibly related problem of lack of parental interest ("California Survey Results," 1975). Among the operational priorities for schools reported by Colorado school districts was meeting public concerns about discipline (Priorities in Education..., 1976). A factor related to discipline, the poorly motivated, was reported as a major concern by Olson (1970). A survey of a statistically valid statewide sample of the population of Oregon revealed that the need ranked first in priority was: "Students need to develop behaviors indicative of self-discipline and respect for authority." (Wright, 1970, p. 35). This was identified as a program concern by adding a fourth "R" - Responsibility - as a basic of education.

Student management and discipline problems are complex, involving lack of interest by both students and parents, low motivation, student failure and other interrelated factors, and concern is widespread. Several implications emerge when reviewing potential discipline problems in science education. Lawrenz (1974) noted that teachers indicated they had more discipline problems with junior high school students in part because the materials were less relevant than were the materials for high schools. When science is taught in an activity oriented mode, the potential problems arising from disciplinary difficulties are likely to be exacerbated by the less rigid structure of such an approach. Finally, the potential for

reduced safety resulting from increased discipline problems presents a clear danger in the science laboratory (Garner, 1972).

Health - Physical Fitness

Educational needs reported in the literature include the physical as well as the intellectual and affective domains. Many states include physical, mental, and emotional well being (Goals and Needs of Maryland Public Education..., 1972; Nyquist, 1974; Seiverling, 1976). In some cases sufficient importance is placed on health education to include it among the categories for funding under Title IV (Ohio Department of Education, 1977). Concern for health and physical fitness is not a characteristic of just the highly urbanized states. Kansas includes physical fitness as a need based upon an evaluation of educational programs in the state (State Educational Evaluation..., 1970). Nearly 7000 people were surveyed in Montana to determine educational needs. Second in order of importance is fitness, the need "to develop habits and skills to maintain physical fitness and mental health" (Colburg, 1975). The need for education to aid in improving and maintaining physical, mental, and emotional well being is widely recognized.

Concern for health and health sciences has long been reflected in the science curriculum. The development of some of the newer science programs such as Human Sciences and Me Now reflect the increased attention to health indicated as a need for education in general.

The preceding listing and discussion of educational needs in no way exhaust the list of needs that were identified in the literature. Those included were needs which appeared often and from a variety of sources in the literature and represent what appear to be the most urgent. The needs

of education are a subset of the needs of society (Turnbull, 1971). To determine education's needs, then, it is necessary to turn to society. This, of course, presents another set of difficulties. In this regard Wright (1970) notes:

> Recognizing the importance of knowing what people think schools should do and finding out what people think are two different things. Mark Twain said the way to get rid of submarines was to boil the ocean; figuring out how to boil the ocean was another problem. (p. 33).

SCIENCE EDUCATION NEEDS

Just as the needs of education are a subset of the needs of society, the needs of science education are a subset of the needs of education. The following needs are those which appear most critical in science education. They derive from legislation, from state educational policy guidelines, from committees and conferences, from research studies and surveys, and in some instances from broader educational needs described earlier.

---

1. Stabilized and improved funding is a critical need in science education.

2. A basic and continuing need is for science education that includes:
   a. Facts, concepts, principles
   b. Inquiry, investigative processes
   c. Interaction of science and society
   d. Appreciations and attitudes
   e. Career knowledge and awareness
   f. Relationships of self and environment

3. Improved science teacher education, particularly for inservice teachers, is an important need.

4. Curriculum and instructional materials are needed that are more flexible, are appropriate for a wider range of student abilities, and that reflect emerging societal concerns.

5. Continuing research in science teaching and learning is vitally needed.

Funding

Improved financing has been widely identified as the greatest single need facing education ("California Survey Results," 1975; "Education Survey," 1976; Wing, 1971; Gallup, 1971). The implications of decreased funding for

science education are not yet, for the most part, well documented in the literature. However, discussions with personnel in various state departments of education reveal several problems that stem from reduced finances. First, and probably most worrisome, was the assignment of teachers to second and third teaching areas, either in addition to, or instead of, assignments to major areas of specialties. In the view of most, this has led, and will continue to lead, to lowered educational quality due to less-adequate teacher backgrounds. A second problem noted was an increase in class size. In addition to potentially lower quality education under this circumstance, there was increased concern with safety in the classroom, particularly if laboratory instruction is involved. A third problem cited was the reduced funds available for purchasing materials, equipment, and supplies. State departments indicate that teachers reflect increasing concern for lower cost materials and for increased inservice assistance as budgets decrease.

Still another problem involves small rural schools and large urban schools competing for the same basis of funding but with quite dissimilar problems. Within each set of problems there are still further compounding factors. For example, in the case of the rural versus the urban schools, the small school typically offers fewer program alternatives under good conditions. In times of reduced budgets the small schools may be disproportionately affected by losing some of the options that they may have had.

A budgetary problem impacting directly at the state level can be seen in the recent trend of fewer supervisors in the discipline areas and altered assignments for state department of education personnel. The number of state science supervisors rose with the increase of funds for science education (notably from NDEA and NSF) and has fallen as monies

are reduced, (Pearson and Fuller, 1969b; Wirt, 1977). State level supervisors are now often operating out of their areas of specialty. Alternatively, many generalists now are attempting to deal with special areas. In either case, this problem increases the difficulty at the school level where teachers are requesting increased inservice assistance from reduced state department staffs.

The problem of funding for science education does not appear to be one to solve simply by channeling money into the educational system. The impact of legislation on education, in general, and on science education in particular, has been discussed earlier in this report. It seems clear that an effective approach would be to establish the priorities or objectives in science education and then fund the program accordingly. In trying to accomplish specific objectives, funding by categorical programs is more effective than is funding by block grants (Wirt, 1977; Milstein, 1976).

Science Education Objectives/Components

The objectives for science education have remained relatively stable over the past 20 years. Carleton, in the introduction to a special issue of The Bulletin of the National Association of Secondary-School Principals, noted that a sound, well-planned program of science could contribute to all the imperative needs of youth as outlined in Planning for American Youth. The most directly served need was No. 6: "All youth need to understand the methods of science, the influence of science on human life, and the main scientific facts of the nature of the world and man" (1953,p. 7).

Shortly after this, of course, considerable federal money, through NSF, was devoted to science education in an attempt to update and upgrade the scientific knowledge of teachers (Kreighbaum and Rawson, 1969; The National Science Foundation Curriculum ...., 1976). The emphasis at this point was on the factual and conceptual knowledge need for competency in science.

Hurd (1960), in the NSSE 59th Yearbook, listed the following objectives of science education:

- Understanding Science - including knowledge and enterprise
- Problem-Solving - involving process and inquiry
- The Social Aspects of Science - interdependence of science and society
- Appreciations - including the endeavore of scientists
- Attitudes - understanding of attitudes of science
- Careers - knowledge of career opportunities
- Abilities - acquire knowledge for improving learning skills

Stolberg et al. (1961), in Planning for Excellence in High School Science, regard science as

> a human enterprise including the ongoing process of seeking explanations and understanding of the natural world, and also including that which the process produces - man's storehouse of knowledge. Science is process and product (p. 15).

Other activities, such as NSF-sponsored curriculum development, also reflected increased concern with the processes of science and science as inquiry (National Science Foundation Curriculum Develoment..., 1976).

During the sixties, state goals and guidelines for science education included both process and product aspects of science and retained features included in the earlier literature. As an example, in A Guide to Science Curriculum Development for Wisconsin, the framework for development included: (1) conceptual structure, (2) processes of science, (3) nature of the scientific enterprise, including philosophy of science and actions of scientist, and, (4) cultural implications of science (A Guide to Science Curriculum Development, c. 1968).

In a recent listing of state goals for elementary and secondary education, Ribble (1973) presented responses from 42 states. General concerns

related to science could be inferred from nearly all states' listings of goals. Specific references to science goals were indicated by 23 states. It should be noted that 19 of the 42 responding states reported no specific science goals for this summary. The distribution of components of science education for the science goals of the states is presented in Table 17 on the following page.

From the table it is apparent that the emphasis is most often placed upon what might be called the structure of science: the facts, concepts and principles. This may be due in part to concern over declining ACT test scores (Table 18).

As indicated in the table, the composite ACT scores have shown a declining tendency since 1965-66. It should be noted, however, that natural science scores have increased in recent years.

A decline in science knowledge as indicated by NAEP scores ("Science Knowledge Declines," NAEP, 1975) may also be a factor in the emphasis on science facts, concepts and principles. Several possible explanations for these declining scores have been suggested including invalid tests, failure of schools, student indifference, increasing family size, and "enjoying more, but learning less" (Welch, 1977b).

Another factor related to the emphasis on the structure of science may be accountability pressure resulting in an emphasis on those factors which can be more readily measured. Or, the emphasis may be related to overall concern with basic skills in education.

Although concern is not yet widely reported in the science education literature, discussions with state level personnel indicate increasing interest in life and work skills related to science, concern for ecological

TABLE 17

DISTRIBUTION OF SCIENCE EDUCATION
COMPONENTS AS REPORTED IN STATE
GOALS FOR EDUCATION

Component	Number of States Including Component
Facts, Concepts, Principles	17
Process, Inquiry, Investigation	8
Science-Society Interaction	3
Appreciation, Attitude	6
Self and Environment	6

TABLE 18

ACT TEST SCORE AVERAGES (MEANS) AND VARIABILITY (SD'S)
FOR SUCCESSIVE YEARS OF TESTED COLLEGE-BOUND STUDENTS

School Year	ACT Natural Science		ACT Comprehensive	
	Mean	(SD)	Mean	(SD)
1964-65	20.4	(6.1)	19.9	(5.2)
1965-66	20.5	(6.1)	20.0	(5.2)
1966-67	20.1	(6.3)	19.4	(5.4)
1967-68	19.8	(6.5)	19.0	(5.5)
1968-69	20.0	(6.4)	19.4	(5.3)
1969-70	20.5	(6.1)	19.5	(5.3)
1970-71	20.2	(6.4)	18.9	(5.6)
1971-72	20.3	(6.5)	18.8	(5.7)
1972-73	20.5	(6.5)	18.9	(5.8)
1973-74	20.6	(6.5)	18.7	(5.8)

(adapted from National Science Foundation Curriculum Development and Implementation for Pre-College Science Education, 1976, p. 537)

problems and for the impact of science and technology on society. It is worthy of note that the third science study by NAEP will include exercises developed to reflect current technological and societal issues as well as content from the traditional science courses. A basic life skills assessment is also being undertaken as part of a pilot study to identify and measure skill deemed by subject matter specialists and lay panels as important for 17 year olds to have in order to cope with life after leaving high school ("Third Science Study...," NAEP Newsletter, October, 1976). In a related view, Hurd, in the same issue of the NAEP Newsletter, says:

> The focus of science teaching over the past two decades has been on inquiry - how we acquire knowledge. In addition, students should be taught how to use knowledge for making decisions about problems and issues important to human welfare. (p. 4).

Teacher Education

Because teacher education has been dealt with in detail elsewhere in this report, this section will be limited to a consideration of the need for improved inservice education.

During the earlier part of the past two decades considerable effort and money were devoted to inservice science teacher education. Inservice programs were supported by Title III funds, by NDEA funds, and by Projects to Advance Creativity in Education (PACE). Some inservice programs were funded by various states and many were funded at the local level. Commercial publishers also conducted some inservice education (Blosser, 1969a, 1969b). The largest single source of support, however, was the National Science Foundation Teacher Institute Program which included the Academic Year Institutes (AYI), Summer Institutes (SI), and the Cooperative-College School Programs (CCSP) as prominent factors in science teacher inservice education (Kreighbaum and Rawson, 1969).

The impact of these institutes was widespread. Schlessinger et al. (1973) report that over half the secondary school science teachers in their national sample had attended one or more NSF institutes. However, with reduced funding from federal sources and increased demands on tighter budgets at the state and local levels, emphasis on inservice science education has declined since the early 1970's. Although a large number of teachers have been involved in the institutes, there is also a large population of science teachers who have not had institute experience as indicated by the teachers in the national survey who reported no institue attendance. White et al. (1974) reported that institute attendees were likely to be more experienced, higher educated, older males from larger schools. This finding, together with an increase in the number of women who are returning to careers after their families are grown, suggests there is a substantial number of

people in science education who could benefit from inservice education. Moreover, at the elementary school level, Steiner et al. (1974) found that the national mean of elementary teachers who had attended an NSF institute was 14%. Thus,there is a potentially large population of teachers with little or no inservice science education experience.

The inservice needs reported by teachers vary. Mertens and Bramble (1976b)report that the needs of inservice education include programs aimed at aiding teachers in dealing with students from minority groups, enabling them to better understand the students' cultural heritage and special needs as related to the course(s) being taught. They also note a particular concern for training in working with the gifted student.

Lawrenz (1974) reported a study in which junior and senior high school teachers in 12 states were asked to rate their own skills. The item receiving the lowest rating was the teachers' knowledge of curriculum techniques. Lawrenz concluded that inservice programs should be in the form of summer institutes and should stress curriculum techniques and the use of evaluation to diagnose learning problems. Individualized instruction was another area of concern along with the need for information about science careers.

Falls and Fryman (1974) surveyed the needs in science and mathematics in the Appalachian region of eastern Kentucky. They found that 92% of the science teachers wanted to learn more about recent advances in science. Approximately 74% felt they needed to improve their understanding of basic science concepts; this is in contrast to the finding reported by Lawrenz which indicated that teachers were not very interested in inservice courses and at improving their knowledge of subject matter. Falls and Fryman also reported that over 50% of the science teachers in the survey had not attended a workshop or similar inservice function in over five years;

half of that group had not had any inservice activity in over ten years. Two-thirds of the teachers indicated a lack of training in technical presentation, demonstrations, testing, questioning techniques, use of audiovisual materials, and a total lack of training in laboratory management.

Stronck (1974) used a questionnaire to determine inservice education needs as perceived by 309 elementary and secondary teachers and administrators. Based upon the results, he recommended that inservice programs concentrate on (1) the coordination of a K-12 science sequence, (2) recent advances in scientific knowledge, (3) the relevancy of scientific concepts to the lives of students, (4) the efficient management of curriculum materials, (5) individualization of instruction, and (6) ways to evaluate the quality of instruction (1974, p 508).

It is clear that needs for inservice education exist. Complete agreement on what the needs are and how they should be handled does not exist. The situation is summarized by Hite:

> Apparently, inservice education is high on everyone's agenda. There are felt needs and there are external incentives . . .
> Unlike the preparation of beginning teachers, inservice education has no tradition of what constitutes a basic program. Different perceptions imply different sets of values--what ought to be <u>the way</u> to undertake professional development. Because values do not lend themselves to technical criticism, each definition may be legitimate for its supporters. The way inservice education is perceived seems to determine the activities and content of programs. Thus, the very different perceptions of inservice education lead to equally different programs in operation. (Hite and Howey, 1977, p. 5)

While it does not relate directly to inservice education, a needs assessment study conducted by Welch (1977b) clearly has implications for science teachers. The study included a sample of 344 science teachers and 167 principals from a 12 state region. The objectives were to: (1) identify needed goals for science education, (2) determine which of several alternative

strategies was seen by principals as the best means for accomplishing these goals, and (3) identify the components (tactics) of that strategy which teachers believed were in greatest need of assistance.

Welch found that science teachers and principals believed that there are three major needs for the functions of science education: (1) information processing and decision making skills, (2) basic skills, and (3) the development of self-esteem. Based upon the principals' responses, the best strategy for attending to these goals is preparation and training of instructors. Three aspects of instructors preparation are of most importance: (1) time available for planning and carrying out the practice of science teaching, (2) support personnel including secretarial and science consultants, and(3) facilities such as office space or storage of equipment.

Based upon the results of the study, Welch concluded that the goals of science education can be better achieved by providing time, support and facilities to teachers.

Curriculum and Instructional Materials

The past two decades have seen more activity related to development and change in curriculum and instructional materials than has any similar period of time in the history of science education. Dede and Hardin (1973) briefly describe the societal forces which challenged the traditional science courses in the secondary schools and which led to curriculum reform. With respect to this activity, Dede and Hardin note:

> The reform movement that emerged from these forces was unique to reform movements in American science education in several ways. First, it attempted to replace the present curriculum rather than revise it. Second, it employed leadership from professional scientists in universities rather than from educators. Third, it used money from foundations and federal grants rather than the usual state and local sources of funding (1973, p. 486).

The changes that this curriculum reform movement were attempting are described as follows:

From	To
1. Student-centered curriculum (personal-social goals).	1. Discipline-centered curriculum (intellectual competency goals).
2. Deductive, teacher-directed telling, drill, memorizing.	2. Inductive, lead-to-discovery experiences, "solve-the-puzzle" motivation.
3. Informational aspects of science; descriptive and applied	3. Student to "behave as a scientist" emphasis on "science as a way of knowing" and on processes; interpretive and theoretical aspects of science.
4. Laboratory work largely divorced from classroom learning; intended to demonstrate, illustrate, or verify known information.	4. Laboratory work an integral part of courses, used to raise problems, test inquiry skills, provide "discovery" opportunities.
5. Teacher chooses sequence of learning materials, builds course on logical organization of information.	5. Instructional packages contain the whole of a teacher's lessons (films, lab equipment, texts, tests, etc.) which are pre-sequenced according to logical structure of discipline.

From (continued . . .)	To (continued . . .)
6. Teacher's preservice training sufficient (and that heavy in professional education and light in knowledge of any discipline).	6. Extensive teacher training in how to use materials.
7. Science as "established" knowledge with emphasis on basic facts.	7. Scientific knowledge ever-changing; useless unless up-dated; attempts to give students tools to update their own knowledge.
8. Course units at uniform level of conceptualization; up to teacher to decide sequence.	8. Course work interrelated; unit build upward on previously learned concepts.
9. Overview of the entire discipline.	9. Understanding a few concepts in depth stressed.
10. Relate science to new technology.	10. Omit relationship of science to technology.

(Dede and Hardin, 1973, p. 486-487)

The results of these reforms, according to Dede and Hardin, were mixed and criticism of the reforms arose which included: 1) the new curricula allowed no room for teacher and student spontaneity, 2) subject matter was overemphasized, and 3) the curricula were too difficult for a majority of the students.

With respect to the last criticism, it is interesting to note that Conant (1959), in The American High School Today, included in his recommendations for science courses the suggestion that a section of chemistry and of physics be offered for students with less mathematical ability but that the difficulty level of these sections be such that those students with less than average ability would have difficulty passing the course (p.73).

The curricula developed for secondary school science had the structure of science as their basis; the emphasis was on basic science and not on engineering or technology (American Association for the Advancement of Science, no date, p. 5). A similar concern existed at the junior high school level

for the teaching of science as a discipline. This concept of discipline included "the recognition of a logic, a structure, and a coherence within a body of knowledge." (Hurd, 1970, p.26). Curriculum development for edementary school science included the agreement that instruction should deal in an organized way with science as a whole, but also that the spirit of discovery should be stressed in science teaching (Karplus and Thier, 1967, p.2). The Educational Policies Commission (1966, p. 27) noted that "To communicate the spirit of science and to develop people's capacity to use its values should therefore be among the principal goals of education in our own and every country."

The new science programs had two common characteristics: a "preference for the abstract (theoretical) or 'pure' science and involvement of the learner in direct inquiry" (Butts, 1969, p. x).

Broudy (1973) notes that theoretical knowledge alone is not sufficient for modern society, that technical know-how is required. However, he argues the case that theory should be included in the science curriculum on the basis that theory is needed to understand and interpret problems encountered in life; the ability to apply science to solve problems is not the same thing as understanding them (p. 232).

It is a blend of the theoretical, the practical, and the relevant in science that should be included in the curriculum. Jacobson (1970) notes four goals for the elementary school science curriculum: 1) to build a world view, 2) to develop some skill in the use of the processes of science, 3) to gain an understanding of the conceptual structures of science, and 4) to gain a better understanding of man and how science and technology affect man and his society.

In considering emerging perspectives for science education in the 1970's, Hurd (1971) identifies a series of priorities:

1. Science must be a viable strand in the education of every student.

2. Technological achievements with all their ramifications throughout modern society constitute a new priority in science teaching.

3. Science should be taught in a social context.

4. A priority for learning science in the 1970's is the formation of those values which may serve to convert knowledge into wisdom and make for responsible social action.

5. The science curriculum ought to prepare students to cope with a world of change.

6. The process of education should provide the student with skills and intellectual attitudes to understand the emerging world and to mediate the future; the priority becomes how best to teach and learn the future.

7. A new educational priority is how to use knowledge for the welfare and advancement of mankind.

(p. 11-18).

In a related vein, discussions with people in various state departments of education reveal increased interest in life skills and work skills as they relate to science education. Discussions with state personnel also indicate concern among science teachers for curricular and instructional materials that are less expensive and more flexible. Of increasing concern is science for the pupil who will not become a scientist, who is not necessarily college bound, but who will be faced with complex decisions.

Hurd (1976) has noted that it is inevitable that science becomes more humanized:

> As science has become inextricably entwined with the economic, social and political fabric of the nation, the social responsibility of science becomes a topic we cannot afford to ignore in the teaching of science. (p. 5)

Research

Suggestions for needed research in science education have been included with nearly every research report, doctoral dissertation, and review of research that have appeared in print. Representative selections will be presented in attempting to deal with this vast quantity. The first type of documentation will include the results of two approaches for establishing research priorities in science education by the National Association for Research in Science Teaching (NARST). The second type will draw upon reviews and summaries of research which have in turn reviewed, analyzed and synthesized hundreds of research studies.

The National Association for Research in Science Teaching (NARST) has produced two sets of priorities for research in science education. The first approach began early in 1974 when officers of the National Association for Research in Science Teaching were approached by representatives of the National Institute of Education (NIE) to inquire into the possibilities that NARST, in cooperation with NIE, would develop a policy statement and establish priorities for research in science education. The officers of NARST accepted the invitation and appointed a small committee, representing diverse views, to develop a statement.

The committee analyzed science education and considered research implications for each of the following areas:

- Goals of Science Education
- Science as an Instructional Medium
- The Domain of Science
- Priorities for Research in Science Education
- Research on Research Styles and Methodology
- Development of Quality

After considerable discussion, the committee chose to concentrate on the domain of science education and to emphasize the eight aspects shown in the following table.

TABLE 19

DOMAIN OF RESEARCH PRIORITIES FOR SCIENCE EDUCATION

Antecedents	Transactions	Outcomes
Teacher Characteristics	Pedagogy	Student Attitudes
Student Characteristics	Learning Environment	Scientific Literacy
Social Imperatives	Implementation of Changes	

(Watson et al., 1976, p. 10)

Based upon their analysis, the Committee made five recommendations for research in science education:

1. Large scale studies are needed to clarify how cognitive and affective outcomes for a wide range of students result from student interaction with differing concepts, instructional materials, experiences, and learning environments established by teachers.

2. The development of values and attitudes toward science and the application of science through technology, as well as coping skills and problem-solving abilities, needs to be clarified within the context of instruction in science. Both cross-sectional and longitudinal studies are desirable.

3. Diagnostic studies, perhaps detailed case studies, are needed to reveal the conceptual and emotional blocks which inhibit some students from developing logical thought in science.

4. Cooperative research efforts between universities are desirable to create large-scale studies of considerable duration and to focus the results back upon educational practice. The studies suggested in 1) above, as well as establishing test reliability and validity, are examples of needed large-scale research efforts. These could be coordinated through existing organizations.

5. Detailed figures on science enrollments in the schools should be gathered annually and published within a year.

195 (Watson et al., 1976, p. iii)

In April, 1976, NARST undertook a second approach to establishing research priorities. The NARST Research Committee was directed to survey the NARST membership to identify those priorities which were perceived to be most important. At the request of the Research Committee, the Science Education Department at the University of Georgia undertook the study. (Butts et al.,1977)

The Delphi technique was selected as a means of establishing research priorities among the NARST membership. In the first phase, a series of research topics was identified in response to a request to all members of NARST to nominate three needed areas of research. Responses from 248 persons listed 729 areas of research. Phase I ended with the categorization of the 729 research nominations, resulting in 35 categories identified by generic statements.

In Phase II, the list of 35 generic statements was mailed to all 780 members who were requested to rate them on a 1 to 10 priority scale.

In Phase III of the study, each respondent from Phase II was requested to reconsider his or her response in relation to those of his or her colleagues. Data from Phase III were analyzed in a manner similar to that for Phase II and yielded a ranking order for the 35 statements.

While the study did not yield the top priority, for research in science education, it did indicate which areas were a high priority. The more highly rated research areas were those characterized by: (1) applying research to teaching or learning, or (2) identifying strategies that facilitate teaching or learning. Implicit in both areas is the potential for changing practices.

Developing or testing theory, developing materials, and pursuing interests in specific populations all were ranked low in the list.

Extensive reviews of research have been published beginning with the Curtis Digests. Many of the needs identified for research in science education have been repeated in several of the reviews subsequent to the Digests. Because these needs have been noted by several reviewers and documented by so many studies, in order to reduce redundancy of citations, they will be presented in the form of a listing without specifying the sources for each identified need. The sources for the reported needs include:

Blackwood and Brown, 1955
Brown, Blackwood and Johnson, 1955
Smith et al., 1955, 1956
Boeck et al., 1956
Fraser et al., 1956
Mallinson, J., 1956, 1961
Washton, 1956
Johnson, 1957
Mallinson and Mallinson, 1957, 1961
Matala and McCollum, 1957
Obourn et al., 1957
Smith and Washton, 1957
Tyler, 1957
Wallen, 1957
Mayor, 1959
Obourn and Boeck, 1960
Hubler, 1960
Boeck, 1960
Smith, 1960
Boeck and Washton, 1961
Smith and Homman, 1961
Metzner and Reiner, 1961
Lucow and Anderson, 1961
Obourn, Blackwood and McKibben, 1962
Wheeler, 1962
Smith, 1963
Atkin, 1964
Belanger 1964, 1969
Briggs and Angell, 1964
Burnett, 1964
Hurd and Rowe, 1964
Van Deventer, 1964
Taylor et al., 1965
Johnson et al., 1965
Lee et al., 1965
Bruce, 1969
Smith, 1969
Robinson, 1969
Welch, 1969, 1971a, 1971b, 1972, 1976
Blosser, 1969a, 1969b, 1976
Haney et al., 1969
Ramsey, 1969
Ramsey and Howe, 1969a, 1969b
Westmeyer et al., 1969
Champlin, 1970
Cunningham and Butts, 1970
Lawlor, 1970
Montean and Butzow, 1970
Ramsey, 1970
Gallagher, 1971
Koran, 1972
Mallinson, G., 1972, 1977
Mayer and Wall, 1972
Trowbridge et al., 1972
Anderson, R.D., 1973
Balzer et al., 1973
Novak, 1973
Voelker, 1973
Helgeson, 1974
Rowe and DeTure, 1975
Herron et al., 1976

- More care in designing research studies and in applying appropriate statistical techniques is needed.
- Research needs to be reported in more detail with attention paid to descriptions of samples, inclusion of reliability and validity information and the like.
- More needs to be learned about those factors which contribute to student learning.
- Research is needed which is carefully designed to contribute to development of a theory of learning.
- There should be a focus on problems which deal with other than local conditions and which can be generalized to a larger population.
- Longitudinal studies, rather than one-shot studies, are greatly needed in science education research.
- An effective, ongoing mechanism for communicating the results of research in science education to the classroom practitioners is needed if research is to improve classroom instruction.

There has been increasingly strong concern over declining achievement reflected in various assessments of students since the 1960's. In view of this concern, perhaps an additional comment related to research is appropriate. There have been many factors suggested as having possible influence on the declining scores. These include: socioeconomic status of family; size and spacing of family; increased holding power of schools; desegregation; mainstreaming; reduced instructional time, either by shortening the school day, by devoting time to other subjects or concerns, or by decreasing the number of school days; less attention to basic knowledge and skills in teaching; impact of television; use of curricula by teachers not familiar, or in disagreement, with the underlying philosophy; less failure of students, or grade inflation; or, improved attitudes indicating that students may be learning less but enjoying science more. While any combination or all of these may contribute to decreased achievement, there is relatively little research that deals

with more than one or two factors at a time; no literature was found that encompassed all the identified factors. Regression analysis in which the amount of variance attributable to certain factors can be determined should be considered in such research to avoid either unduly crediting or disregarding possible contributing elements. Similarly, care must be taken in interpreting existing research which does not indicate the amount of variance accounted for by reported factors.

VI. SUMMARY AND TRENDS

The statements presented in this section are derived from the review of the literature and from the analyses reported in the preceding sections of this report. The order of listing does not necessarily imply an order of importance.

Practices and Procedures

- Enrollments have been increasing but are beginning to decline, with elementary enrollments declining earlier than secondary.
- The effect of enrollment change may be heightened by emigration of students.
- Just as increasing enrollments had an impact on schools, decreasing enrollments will impact on schools, particularly financially.
- Percentage of students enrolled in science has increased until 1973-74 and since has remained relatively stable.
- Since 1955 there has been an increase in student-centered and hands-on instruction but a substantial percentage of students are not involved with such procedures.
- Stated objectives for elementary school science have not changed significantly since 1955.
- Objectives for secondary school science appear to be in transition.
- There are far more alternatives for instructional materials currently than in 1955. Relatively few of these are designed for use in an articulated program.
- The individual classroom teacher is still the primary mode of instruction in most classrooms. Less than 10% of the schools have used innovative practices such as modular scheduling, television, or computer assisted instruction in any consistent manner.

- The variables for effective teaching are generally agreed upon and the most important, with the current mode of instruction, is the teacher.

- Perceived barriers to effective science teaching have not changed appreciably over the past 20 years.

- About 50% of the students take no science after grade ten.

- Class sizes have been reduced between 1955 and 1975.

Science Teacher Education

- State certification criteria still do not reflect those proposed by professional associations in that the professional organizations call for an increase in science content.

- Over the years the guidelines proposed by professional organizations have broadened their focus from science content to include such things as interpersonal relations and ability to deal with societal problems. Guidelines related to content areas are the most likely to be implemented, however.

- Preservice programs in science education reflect increased field experiences and, in general, increased time in the education component.

- Even though more science is being taught at the elementary level, elementary teachers are most comfortable when science consultants are available.

- Although secondary school science teachers are currently younger and better educated than in the 1950's there is still a critical need for inservice education, both as perceived by the teachers and as indicated by research.

- While NSF and OE did offer intensive institutes in the late 1960's and early 1970's, the majority of teachers currently teaching have not participated in these. This is especially true for elementary teachers.

- The average tenure for teaching was about eight years in the early 1970's, it is currently increasing. This has implications for inservice education since it appears that the more recent graduates are those more likely to go back to school.

- The bulk of the science instruction for the secondary program is in the junior high school (nearly 50% of the students take no science after tenth grade). this level has the teachers with the least adequate content preparation, poorest facilities, and least certification programs available.

- Teachers are being impacted upon by the press for accountability, the back to basics movement and textbook controversies, but these are rarely the kinds of issues dealt with in their prepartion.

- There is a critical need for preservice and inservice science education to be viewed and dealt with as a continuous program rather than as discrete entities handled by two different sets of people.

Controlling and Financing Education

- The influence of state governments on science education has increased markedly since 1955.

- There is extreme variation in state control and influence, but regional patterns do exist.

- Some examples of areas in which considerable state control is exerted are school organization, school curriculum, teacher certification and financial support for the schools. Science education has been impacted both negatively and positively by state influences.

- The percentage of financial support for the schools from federal and state sources has increased since 1955; the percentage of financial support from local sources has decreased since 1955.

- Federal support for science education has declined since the late 1960's.

- Since state support tends to follow federal trends, state support for science education has also declined and is likely to continue to do so.

Needs Assessment Efforts

- The greatest single need facing education is an improved program of financial support.

- Pressure for accountability has increased markedly within the past ten years.

- Nearly all states have some form of accountability or assessment procedure.

- Achievement scores have declined since the 1960's; many possible contributing factors have been suggested but additional research is needed to clarify related circumstances.

- There is increasing emphasis on basic skills; knowledge of science is rarely considered basic.

- Science education is rarely included in state needs statements. When it is included, it increasingly reflects concern for life skills and work skills.

- An important and complex need is for equal educational opportunity.

- The major objectives in science education have not changed markedly over the past 20 years. The emphasis is beginning to shift, however, at the secondary school level

- Improved science teacher education, especially inservice education, is an important need.

- Continuing research in science teaching-learning is vitally needed, however, the results of that research which has already been done needs to be better communicated and applied.

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APPENDIX A

TERMS USED IN SEARCH OF ERIC DATA BASE

TERMS USED IN SEARCH OF ERIC DATA BASE

Searches were limited by the terms Science and Mathematics (partial descriptors) respectively.

1. Student Outcomes

Student Needs
Student Attitudes
Student Interests
Student Opinion
Student Problems
Student Reaction
Achievement
Achievement Need
Teacher Attitudes
Teacher Characteristics
Teacher Distribution
Teacher Influence
Teacher Responsibility
Teacher Role
Academic Achievement
Administrative Change
Administrative Problem
Administrator Attitudes
Community Attitudes
Community Change
Community Influence
Community Involvement
Mathematics Teachers
Science Teachers

2. Needs Assessment

Achievement Tests
Educational Needs
Norm Referenced Tests
State Programs
Statistical Data
Student Evaluation
Technical Reports
Test Results
Academic Achievement
Academic Performance
Educational Objectives
Student Testing
Testing Programs
Educational Assessment
Program Effectiveness
National Surveys
Educational Assessment

2. Needs Assessment (continued)

State Surveys
Statistical Surveys
Needs
Student Needs
Achievement Need
Educational Policy
Problems (txt)
Enrollment Trends
Educational Trends

3. Teacher Preparation

Teacher Certification
Credentials
Teacher Certificates
Teacher Education Curriculum
Teacher Employment
Teacher Qualifications
Teaching Skills
Performance Based Teacher Education
Preservice Education
Inservice Teacher Education
Science Institutes
Summer Institutes
Teacher Background
Teacher Evaluation

4. Facilities/Equipment

Facilities (txt)
Greenhouses
Laboratories
Planetariums
Equipment
School Planning

5. Effectiveness/Efficiency

Cost Effectiveness
Educational Assessment
Evaluation Criteria
Educational Accountability
Management by Objectives
Performance
Teacher Effectiveness
Performance Contracts
Productivity
Program Effectiveness
Responsibility
School Responsibility
Educational Improvement
Educational Innovation

5. Effectiveness/Efficiency (continued)

Educational Economics
Organizational Effectiveness
Resource Allocations
Educational Responsibility
Effective Teaching

6. Student Characteristics

Academic Ability
Student Ability
Average Students
Low Ability Students
Academic Aptitude
Student Characteristics
Student Evaluation
Student Interests
Student Motivation
Student Science Interests
Student Self Image
Attitudes (txt)

7. Curricula Patterns

Curriculum (txt)
Program Descriptions
Course Organization
Units of Study (Subject Field)
Course Description
Science Course Improvement Project
Instruction

8. Career/Success

Science
Mathematics
Career Choice
Career Education
Career Planning
Careers
Science Careers

9. Research

Evaluation
Research Reports

APPENDIX B

KEY WORDS FOR SEARCHING

DISSERTATION ABSTRACTS INTERNATIONAL

KEY WORDS FOR SEARCHING

DISSERTATION ABSTRACTS INTERNATIONAL

The term EDUCATION should be used as a major term, used as an and term with the list. To avoid a large number of false hits, the combined term PHYSICAL EDUCATION should be used as an and not term.

Anatomy
Astronomy
Atom
Atomic

Biochemical
Biochemistry
Biological
Biology
Botany

Cell
Cells
Chemical
Chemistry
Conservation

Density
DNA

Earth
Ecological
Ecology
Electric
Electrical
Electricity
Electromagnet
Electromagnets
Electromagnetic
Electron
Electronic
Electronics
Electrons
Element
Elements
Engineering
Environment
Environmental
Evolution
Experiment
Experiments

Field
Force
Forces

Gas
Gases
Genetic
Genetics
Geological
Geology

Ion
Ionic
Ions

Kinetic
Kinetics

Laboratory
Light
Liquid
Liquids

Magnet
Magnetic
Magnets
Marine
Mechanical
Mechanics
Medical
Meteorology
Microbiology
Model
Models
Molecular
Molecule
Molecules
Motion

Natural
Nature
Nuclear
Nucleus

Oceanic
Oceanography
Oceanology
Oxidation

Particle
Physical
Physics
Physiological
Physiology
Planetarium

Radiation
Radio
Radioactive
RNA

Science
Scientific
Sciences
Sea
Sound
Space
Speed

Velocity
Volume

Weather

Zoology
Zoo
Zoos

APPENDIX C

ORGANIZING CHECKLIST FOR STATE DEPARTMENTS OF EDUCATION DOCUMENTS

ORGANIZING CHECKLIST

DOCUMENTS

Type of Document	Year			
	1955-59	1960-64	1965-69	1970-now
I. Survey or Summary of Information				
-Enrollments				
-by courses/levels				
-sex ratios				
-socioeconomic ratios				
-attrition/drop out rates				
-Curriculum/Course Offering				
-required				
-elective				
-special program/student groups				
Curriculum Materials Usage				
-texts				
-supplemental materials, etc.				
-Instructional Practices				
-Teacher Information				
-work load				
-certified--noncertified				
-in-area--out-of-area				
-number of teachers teaching each course/level				
-degrees, advanced work				
-specialists/department heads				
-Equipment/Facilities				
-Financing/Budgeting				
-state expenditures for science, math, social science				
-state supervisor budget				
-efficiency/cost effectiveness of program				
II. Policies, Regulations, Mandates				
-Curriculum and Instruction				
-required courses, scope and sequence				
-special programs (special groups, EMR, etc.)				
-graduation requirements: credits, courses, performance, competence, etc.--exemptions.				
Textbook or Curriculum Adoption				
-adoption lists				
-scope and sequence				
-process of change				

Type of Document	Year			
	1955-59	1960-64	1965-69	1970-now
II. Policies, Regulations, Mandates (Cont.)				
-Teacher Preparation -certification -re-certification -maintaining certification				
-Accreditation Requirements -schools -colleges and universities (teacher education)				
-Accountability -plans, summaries				
III. Guidelines, Units, Syllabi				
-Required Courses				
-Elective Courses				
-Special Topics (cross disciplinary, etc.)				
IV. Testing, Evaluation				
-Pilot Testing of Programs/Materials				
-Achievement				
-Attitudes				
-Instruments/Units of Analysis				
V. Planning Documents				
-Needs Assessment				
-Statement of Needs				
-Systematic Process/Components, Persons Involved				
-Use and Purposes of Planning Information				
-Plans/Policy Statements -three year plans, etc. -staffing patterns				
VI. Legislation				
-Any Pending Legislation Related to Education				

GLOSSARY OF ACRONYMS

AAS	American Association for the Advancement of Science
AACTE	American Association of Colleges of Teacher Education
ACE	American Council on Education
ACT	American College Testing Program
AETS	Association for the Education of Teachers in Science
AIR	American Institutes for Research
AYI	Academic Year Institute
BSCS	Biological Sciences Curriculum Study
CBA	Chemical Bond Approach
CBTE	Competency Based Teacher Education
CCSP	Cooperative College School Program
CEEB	College Entrance Examination Board
CHEMS	Chemical Education Material Study
COPES	Conceptually Oriented Program in Elementary Science
EPIE	Educational Products Information Exchange
ERIC	Educational Resources Information Center
ESEA	Elementary and Secondary Education Act
ESCP	Earth Science Curriculum Project
ESS	Elementary School Science
ETS	Educational Testing Service
HEW	Department of Health, Education and Welfare
IPS	Introductory Physical Science
ISCS	Intermediate Science Curriculum Study
ISIS	Individualized Science Instructional System

LEA	Local Education Agency
MINNEMAST	Minnesota Mathematics and Science Teaching Project
NAEP	National Assessment of Educational Progress
NARST	National Association for Research in Science Teaching
NASDTEC	National Association of State Directors of Teacher Education and Certification
NCATE	National Council for Accreditation in Teacher Education
NCES	National Center on Education Statistics
NDEA	National Defense Education Act
NEA	National Education Association
NIE	National Institute of Education
NSF	National Science Foundation
NSTA	National Science Teachers Association
PACE	Projects to Advance Creativity in Education
PBTE	Performance Based Teacher Education
PSSC	Physical Sciences Study Curriculum
SAPA	Science-A Process Approach
SCIS	Science Curriculum Improvement Study
SAT	Scholastic Apptitude Test
SEA	State Education Agency
SES	Socio-economic Status
SI	Summer Institute
SSMA	School Science and Mathematics Association
UPSTEP	Undergraduate Pre-service Teacher Education Program
USMES	Unified Sciences and Mathematics in the Elementary School